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January 2015
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Science Reporter

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Space Spinoffs for All!

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COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH

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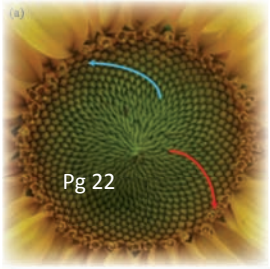

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Science Reporter

MOM's Momentous Moment

The feature articles **India Makes it to Mars in the First Attempt** by T.V. Venkatesaran and **MOM's Resounding Success** by Piyush Pandey in the November issue of SR have provided a glimpse of the

successful flight of Mangalyaan. This space feat is a bright feather in the cap of ISRO and will surely spur the scien sts to undertake more ambitious projects such as Chandrayaan-2 (unmanned lunar landing and surface explora on), Aditya-1 (placing a satellite in 2015-16 in near-sun orbit for study of solar energy and solar winds) and putting an astronaut in near-earth orbit in 2020. For their reless efforts and for upholding the name of the country the scien sts should be rewarded by a grateful na on.

It may perhaps be men oned that roughly a month a4er MOM's insertion in Mars orbit an unmanned NASA's supply rocket exploded within seconds of lift-off from Wallops Flight Facility, Virginia. The star-crossed Cygnus cargo ship atop the powerful Antares rocket, built by Oriental Sciences Corpora on, was supposed to dock with Interna onal Space Sta on. NASA has a rich experience in launching satellites but this mishap shows that disasters can happen any me. To avoid its fair name being sullied ISRO should give top priority to safety concerns.

Dr. S.K. Gurtu, Jaipur

India's Mars Odyssey

The two articles in the November 2014 issue of *Science Reporter* rela ng to India's highly successful Mars mission were very informa ve and inspiring. The fact that the failure rate in Mars missions worldwide has been a staggering 58% —25 failures in 43 a<empts – speaks volumes about the Indian success story. The en re mission involved utmost precision and planning and also incorpora on of intelligent opera ons to be able to communicate with the probe at a distance of about 680 kilometres.

We should all be very proud of the feat that ISRO scien sts have achieved in the very first a<empt and that no country has been able to do before.

Sumit Tiwari, Lucknow

Exciting Feat

The first-hand account of the excitement in the Mars Mission Complex was very well shared by T.V. Venkateswaran in his article **India Makes it to Mars in the First Attempt** (November 2014). One can only imagine the pulsa ng dynamics and anxiety while India was on the verge of achieving a milestone. Time and again India's space research organiza on has given us moments to be happy and proud of. We hope that more such proud moments are in the offing and *Science Reporter* will bring them to us.

Satendra Garg
Sholapur

Harmful Smoke

The Editorial **(E-cigarettes – Harmless Smoke?)** in the November issue of *Science Reporter* is indeed timely. It is unfortunate that our young brothers and sisters get taken up by new fads and invariably end up harming themselves in the long run. Obviously, where there is smoke there is bound to be some amount of damage to health. Besides, as men oned in the Editorial, this could be just a stepping stone to addiction to other hard drugs.

The government should indeed examine the issue carefully and take necessary steps to ward off the dangers that this new fad could unleash.

Ehtesham Khan
Srinagar, J&K

Tortured Turtles

Thanks a lot for a highly informa ve and lucidly written article on the Olive Ridley sea

turtles (November 2014). It touches the heart with a deep attachment to the turtles. Our government should be more proactive in implemen ng the policies for their conserva on and we should make the common masses more aware of the importance of these turtles.

Gyanaranjan Sahoo
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Nobel Insight

I have been reading *Science Reporter* for the past ten years. The article **Nobel Laureates in Chemistry – An Analysis** was well written and provides an insight into the importance of chemistry for mankind.

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Science Reporter
Wishes Its Readers
A
Very Happy
New Year
2015!

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Sit Less, Live More

Move more to live more, seems to be the message coming out of a slew of some recent studies. The ominous corollary, however, is more worrisome – the longer you sit during the day, the more you increase the odds of dying early from all causes, including heart disease, cancer, obesity, and type 2 diabetes.

For instance, in a 2014 study, Seguin, Buchner, Liu, et al. (*American Journal of Preventive Medicine*, February 2014), found that women who sit for long, uninterrupted periods not only gain weight but also increase the likelihood of an un' mely death.

Then there's a six-month study by the Swedish Per Sjogren, a professor at Uppsala University, who examined overweight people in their 60s in terms of sitting ' me, amount of exercise, and length of their telomeres (*British Journal of Sports Medicine*, 3 September 2014). Telomeres are present at the ends of chromosomes protecting the genes on the chromosome from damage. As a person gets older, the telomeres get shorter. The process con' nues un' l the telomeres cannot shorten any further, ultimately causing cell death. So, the length of the telomere could give an indica' on of age. Several research studies have shown a positive correla' on between longer telomeres and reduced risk of developing heart disease, type 2 diabetes, and some forms of cancer.

Per Sjogren in his study found that telomeres lengthened in the group that exercised and shortened their sitting ' me. In effect, what he and his colleagues are saying is that the longer you sit the more damage you do to your telomeres. The researchers suggested that everyone should take short breaks from sitting.

An Australian study published in the 26 January 2010 issue of the journal *Circulation* says that those who watched television for four or more hours a day were almost 80% more likely to have died of cardiovascular disease over the course of the study than those who watched fewer than two hours a day.

In a recent article in *Scientific American* (**Killer Chairs**, November 2014), James Levine, an endocrinologist who co-directs the Obesity Program at the Arizona State University, says that in the past 16 years there have been 18 studies, covering 800,000 people, all of which end up with the conclusion that "chairs are lethal".

Levine believes that more than diet it is inactivity that is more to blame for health problems. Lack of movement slows metabolism reducing the amount of food that is converted to energy, which gets converted to fat. It is easier to change a sedentary way of life than to change ea' ng habits, he says. Levine's laboratory has even designed a treadmill desk to allow office workers to do their jobs while moving and redesigned classroom desks so that children can swing their legs.

The studies should ring warning bells for those who either follow sedentary lifestyles out of choice or those who are forced to sit for long periods of time in offices. The take-home message: If you want to live longer, get your activity meters ticking, take out time for periodic breaks from sitting to get up and move, and make a list of tasks that you can perform while walking.

Hasan Jawaid Khan

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CONTROL EATING HOURS TO CONTROL YOUR WEIGHT

GIVE off eating late at night and you could stave off high cholesterol, diabetes and obesity. A new study by researchers at the Salk Institute cautions suggests that confining caloric consumption to an 8- to 12-hour period could even be tried out as a potential weight-loss method.

The results, published December 2, 2014 in the journal *Cell Metabolism*, add to mounting evidence suggesting that it's not just what we eat but when we eat it that ma) ers to our health.

In 2012, Satchidananda Panda, a Salk associate professor, showed that mice which were fed a high-fat diet, but allowed access to that diet for only eight hours per day, were healthier and slimmer than mice given access to the same food for the whole day, even though the two groups consumed the same number of calories. The new study shows the benefits of time restriction is surprisingly more profound than initially thought and can reverse obesity and diabetes in animal models.

The authors demonstrated that time restriction be) er synchronizes the function of hundreds of genes and gene products in our body with the predictable time of eating.

In the new study, Panda's group subjected nearly 400 mice, ranging from normal to obese, to various types of diets and lengths of time restrictions. They found that the benefits of time-restricted feeding showed up regardless of the weight of the mouse, type of diet and length of the time restriction (to some degree).

Regardless of whether their diets were high in fat, fat and sucrose or just fructose, mice that were given time restrictions of 9 to 12 hours-and consumed the same amount of daily calories as their unrestricted counterparts-gained less weight than the controls, researchers found.

In particular, variations in the time window in which the mice were allowed to eat a high-fat diet-including 9-, 10- and 12-hour periods-all resulted in similarly lean mice. For a 15-hour group, the benefits conferred by time restriction became more modest.

Researchers gave some of the time-restricted mice a respite on weekends, allowing them free access to high-fat meals for these two days. These mice had less fat mass and gained less weight than the mice given a freely available, high-fat diet the whole time. In fact, the mice that were freely fed just on weekends looked much the same as mice given access to food 9 or 12 hours a day for seven days a week, suggesting that the diet can withstand some temporary interruptions.

More importantly, for the mice that had already become obese by eating a freely available high-fat diet, researchers restricted their food access to a nine-hour window. Although the mice continued to consume the same number of calories, they dropped body weight by five percent within a few days. Importantly, eating this way prevented the mice from further weight gain (by about 25 percent by the end of the 38-week study) compared to the group kept on the freely available high-fat diet.

(www.sciencedaily.com)

RATIONAL MONKEYS

HUMANS often assume that a higher price tag implies be) er quality. The Capuchin monkeys, however, are smarter, according to a new Yale study appearing in the open-access journal *Frontiers in Psychology*. An earlier study showed that people think a wine labeled with an expensive price tag tastes be) er than the same wine labeled with a cheaper price tag. In other studies, people thought a painkiller worked be) er when they paid a higher price for it.

The Yale study shows that monkeys seem to be more rational. Rhia Catapano, a former Yale undergraduate who ran the study as part of her senior honors thesis, along with colleagues designed a series of four experiments to test whether capuchins would prefer higher-priced but equivalent items. They taught monkeys to make choices in an experimental market and to buy novel foods at different prices. Control studies showed that monkeys understood the differences in price between the foods. But when the researchers tested whether monkeys preferred the taste of the higher-priced goods, they were surprised to find that the monkeys didn't show the same bias as humans.

The researchers think that differences in the response of humans and capuchins could stem from the different experiences that monkeys and people have with markets and how they behave. For humans, higher price tags often signal that other people like a particular good. Our richer social experiences with markets might be the very thing that leads us – and not monkeys – astray in this case.

(www.sciencedaily.com)

MIDORI PRIZE FOR BIODIVERSITY GOES TO AN INDIAN

AN Indian has bagged the MIDORI Prize for Biodiversity for the year 2014 along with Alfud Oteng-Yeboah of Ghana and Bibiana Vila of Argentina. It was a happy coincidence that an Indian received the prize at the COP-12, held during 6-17 October 2014 in which India, chairing the COP-11 passed the baton to South Korea, its host country.

Prof. Kamal Bawa, the founder President of the Ashoka Trust for Research in Ecology and Environment (ATREE), Bangalore, who also has been teaching at the University of Massachuse) s, Boston, USA, for the last four decades has made contributions to biodiversity science through research on conservation and livelihoods in biodiversity hotspots. He has published several research articles and books on the subject and his recently published books have highlighted the biodiversity hotspots of the Western Ghats and the Himalayas. He has also discovered new modes of reproduction in tropical forest trees, developed a new class of genetic markers and new tools for conservation, explored synergies between conservation and social goals such as poverty reduction, and identified conservation priorities in biodiversity hot spots.

The Ashoka Trust for Research in Ecology and Environment (ATREE), established by Prof. Bawa, has emerged as a major research centre for biodiversity conservation and sustainability development, which, through its seven satellite centres in India has been developing innovative approaches to conservation and sustainability science. Recently it has launched its own Academy for Conservation Science and Sustainability Studies to carry on interdisciplinary research and academic studies.

As the President of the Association for Tropical Biology and Conservation, Prof. Bawa has influenced the direction of conservation science, action and policy and guided the development of a strategic plan for conservation for the 21st Century. He is also a part of the international panel on biodiversity in agricultural systems and has played a key role in the development of strategic conservation plan for the Western Ghats and the Eastern Himalaya biodiversity hot spots. Prof. Bawa is also the recipient of the first Gunners Award (2012), a major international award for biodiversity.

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LETTUCE SEE THE FUTURE

IN Japan, Indoor Farms in Miyagi Prefecture are being developed to bring smile to the starving millions. The great hope is based on a LED-lit indoor farm, which is producing 10,000 le) uce heads each day from July 2014.

Shgeharu Shimamura, a Japanese physiologist, focused on a semiconductor factory the size of half of a football pitch. He wanted this unprofitable factory to produce vegetables. So he fitted LED fixtures, his aim being to control the climate in the factory in such a manner that it would be conducive to the growth of vegetables. This will ensure that the crop would not be damaged due to drought, natural disasters and crop diseases.

Shimamura took the help of the American multinational General Electric (GE) for lighting up the indoor farm with LED's. Thus, the farm could create artificial light day and night. He used purple lighting, as produced by LED, to mimic night. Similarly in the morning there was dim light, the intensity of which would go on increasing till noon. And then it steadily decreases till sunset.

This arrangement enables the plants to perform their usual photosynthesis in the day, and breathing at night. Care was taken not only to control the lighting, but also temperature and humidity of the environment. A great advantage of this method is that the water requirement is cut down by 99%, as needed for such plantation outdoors. The result has been spectacular and astonishing. Le) uce produced from the farm is full of vitamins and minerals, even though they have grown two and a half times faster, as compared to outdoor farms.

The physiologist Shimamura ingeniously applied his practical knowledge in plant biology to the hardware of the LED. His farm has 17,500 LED lights on 18 cultivation racks, reaching 15 levels high.

It may be mentioned that Phillips Company in partnership with Green Sense Farms, has also produced le) uces, leafy greens and herbs in an Indian-based vertical farm. It is expected to repeat Shimamura's astounding results.

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CREATING 3D SHAPES IN MID-AIR

TECHNOLOGY has changed rapidly over the last few years with touch feedback, known as haptics, being used in entertainment, rehabilitation and even surgical training. New research, using ultrasound, has developed an invisible 3D haptic shape that can be seen and felt.

A research paper, published in a recent issue of *ACM Transactions on Graphics* demonstrates how a method has been created to produce 3D shapes that can be felt in mid-air.

The research, led by Dr Ben Long and colleagues Professor Sriram Subramanian, Sue Ann Seah and Tom Carter from the University of Bristol's Department of Computer Science, could change the way 3D shapes are used. The new technology could enable surgeons to explore a CT scan by enabling them to feel a disease, such as a tumour, using haptic feedback.

The method uses ultrasound, which is focussed onto hands above the device and that can be felt. By focussing complex pa) erns of ultrasound, the air disturbances can be seen as floating 3D shapes. Visually, the researchers have demonstrated the ultrasound pa) erns by directing the device at a thin layer of oil so that the depressions in the surface can be seen as spots when lit by a lamp.

The system generates an invisible 3D shape that can be added to 3D displays to create something that can be seen and felt. The research team have also shown that users can match a picture of a 3D shape to the shape created by the system.

Image courtesy of Bristol Interaction and Graphics group, University of Bristol, copyright © 2014 *(www.sciencedaily.com)*

EVOLUTION IN ACTION

SPECIATION, the formation of new species from an ancestral species takes a very long time; yet there are evolutionary steps that can be observed within our life-time. Evolutionary action is easiest to observe in species with quick generation turn-over.

Richard Lenski has studied the evolution of twelve *Escherichia coli* populations from a single ancestral strain. Over 50,000 generations of *E. coli* have been seen and the differences in genetic changes between each population were noted. The study has provided evidence of how evolution occurs.

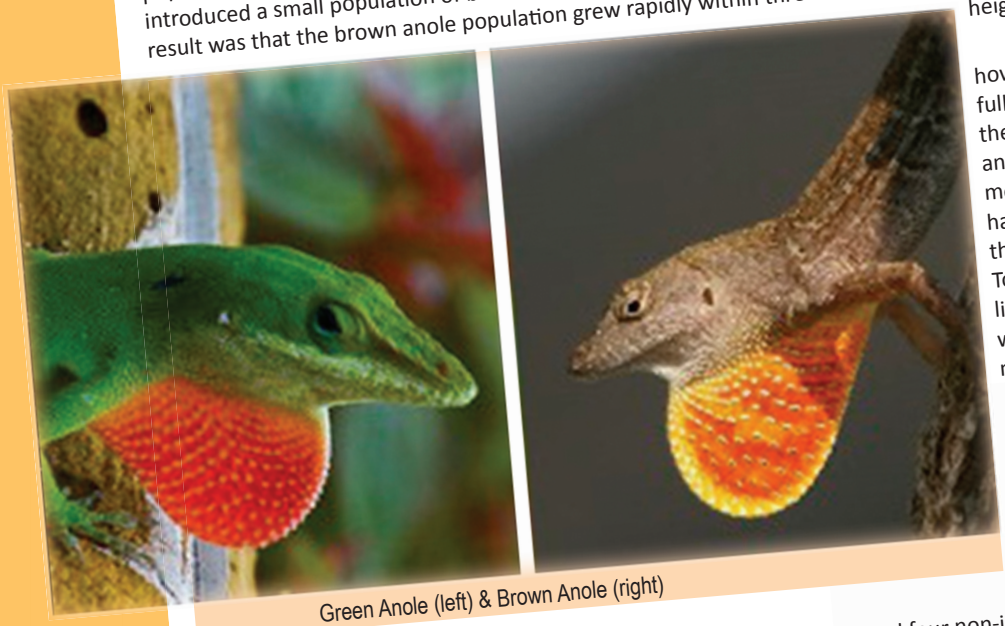
Before the industrial revolution in England, the peppered moth *(Biston betularia)* had a light, mottled colour which was a good camouflage against predators. After the industrial revolution, 95% of the peppered moths showed dark colouration. The light-coloured moths lost their advantage of camouflage, as light surfaces were darkened by pollution and so light-coloured moths were eaten more frequently by birds. This example stands as a major shift in species caused by mutation leading to variation and natural selection.

Peppered maths

On islands off the coast of Florida scientists studied the swift adaptive changes among green anole population whose habitats were disturbed by the introduction of brown anole from Cuba. Anole is a genus of Iguanian lizard belonging to the family Dactyloidae. These lizards are mainly insectivorous. They have readily identifiable features like dewlaps (Throat fan) made of erectile cartilage and toes adapted to cling to many different surfaces. They forage on the top of the trees or trunk or underlying shrubs.

These divergences in habitat are accompanied by morphological changes primarily related to moving on the substrate. Those moving on the twigs have short limbs and those moving on trunk have long limbs. This demonstrates that adaptive radiation can be predictable based on habitat encountered.

In 1995, Todd Campbell of the University of Tampa chose six islands among Spoil islands of Florida with resident population of the green anole *(A. carolinensis)* and recorded the height at which the lizards were perching. He then introduced a small population of brown anole *(A. sagrei)* to three of the islands, leaving the other three undisturbed. The result was that the brown anole population grew rapidly within three months making the green anoles to perch at greater heights.



Green Anole (left) & Brown Anole (right)

On the control islands (undisturbed) however green anoles were making full use of the tree from the ground to the top. Earlier studies had shown that anoles perching at elevated heights have more adhesive toepads because they have more lamellae grooves that allow the digits to stick be) er to surfaces. In Todd Campbell's experiment green anoles living on the islands, where brown anoles were introduced, had larger toepads and more lamellae.

The scientists observed the changes in a ma) er of 15 years or about 20 generations of the lizard. They could witness the process of evolution. The scientists sought to establish whether the longer sticker pads were passed on to the next generation.

They collected gravid *A. carolinensis* females from four invaded and four non-invaded islands in 2011, raising their offspring in identical condition. The larger sticker toe-pads persisted in the laboratory-bred offspring conceived on the invaded islands. Their study adds to the evidence that evolutionary changes can occur very rapidly.

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Space Inventions for all

SWATI SAXENA

Most of us will perhaps never be able to go into space. But each one of us comes in contact with products that are spinoffs of space research. A number of new technologies and products born out of research in space technologies continue to improve our daily lives.

WHEN Neil Armstrong famously spoke of "one giant leap for mankind," he was not talking about the moon boots that he wore. But did you know that today's athletic shoes have borrowed heavily from the technology of the moon boots?

Specially-made boots were designed for the Apollo missions to put a spring in the astronauts' steps while at the same time providing ventilation. Shoe companies worldwide have tweaked this technology to construct shoes that lessen the impact on your feet and legs.

In the last sixty odd years of space history, humans have come up with some of the most outstanding advances to make survival possible in space. People from diverse streams ranging from physicists to biologists and medical doctors to engineers have put their brains together to develop technologies that have helped send humans to as far as moon and successfully brought them back alive.

Many of these spinoffs from space research have found their way into our day-to-day lives. While using most of these technologies, we don't even realize that their first application was actually for the astronauts or space vehicles traveling thousands of miles in the sky.

One of the most important challenges for the human space program was developing food that could be consumed safely by astronauts in space. Their food needs to have several qualities: it should last for long, should preserve the nutrients and provide astronauts with maximum benefits possible with minimum intake. This research has found its way to several healthy food options available in the market today, for example, high quality preservatives, dry milk, etc.

The robotic technology initially developed primarily for aerospace applications such as collecting rock samples from moon, performing space vehicle repairs, and undertaking controlled operations is now widely used in industries, manufacturing plants and hospitals. Space research also helped refine the technology that

The SCAMP® apparatus tied to the backpack (L) Firefighter, (R) Astronaut space suit. Credit: NASA and National Space Society (NSS)

"Arctic Freeze" Do-it-yourself auto air-conditioning recharger. *Credit: IDQ Inc. (www.idqusa.com)*

Design modifications such as vortex generators to control flow separation on airfoils on airplanes and spacecrafts have been tested and implemented on road vehicles as well. The nose of the rocket is designed to reduce the drag and provide the streamline flow that is similar to several current cars.

led to lightweight, cordless medical instruments, hand-held vacuum cleaners and other battery-powered tools.

High resistance and tough materials needed for space vehicles, space suits and satellites have resulted in accelerated, advanced material research. Now, high temperature resistant alloys, lightweight and tough composite materials are used in several land-based applications such as cars, wind turbines, gas turbine engines, medical equipment, etc.

Let's take a look at some such applications that are a direct result of space research.

Breathing Apparatus

It is well known that there is a microgravity environment and lack of air in space beyond the Earth's atmosphere. Therefore, astronauts need a breathing apparatus that works in zero gravity and is able to sustain the harsh conditions. This technology called SCAMP (Supercritical Air Mobility Pack) was developed and used in the breathing apparatus used by astronauts going for Apollo and US Space Shuttle programs.

It uses supercritical cryogenic air at -196˚C stored in a cryogenic vacuum container. Very soon, it found applications on the ground. It is today used in emergency medical services and industries such as mining where the environment might be too toxic to breathe, tunnels or narrow gaps where the rescue team might need air supply, fire fighters fighting with flames in a smoke-filled room, or for military purposes in case of a toxic chemical or biological warfare attack.

The SCAMP® system can produce a flowstream irrespective of its orientation in the gravity-free region. The requirements set forward for the space applications were: continuous supply for more than 30 minutes, equipment thickness not more than 5.5 inches, and light weight as compared to conventional equipment which uses high pressured bottles.

SCAMP® is able to store at least double the amount of air stored in a high-pressure container and has double supply time. In addition to the air supply, it also cools the body as SCAMP® absorbs a large fraction of body heat. The heat gets transferred from the body to the breathing air through fluid transfer loops between the suit and heat exchangers designed in SCAMP® backpack.

Improved Refrigerant

Another challenge faced by astronauts in space is the extreme temperature that they have to deal with while inside and outside spacecraft. The gases present in the Earth's atmosphere shield us from harmful sun rays and create a greenhouse gas effect that keeps us warm even at night.

Satellites such as our moon (260 to -279˚F) and inner planets like Mars encounter extreme climate and temperatures in which the human body cannot survive. Space agencies wanted to develop a chemical/mechanical heat pump to be used as a thermal control for astronauts while inside the spacecraft.

A NASA funded program developed a technology that enhanced the cooling/heating effect of a system and hence provided improved temperature control for space applications. An additive called QwikBoost™ (developed by Mainstream Engineering Corporation) results in increased system performance of vapor compression refrigeration systems, air conditioners, and heat pumps i.e., reduced overall energy consumption.

Hairstyling Iron from Farouk Systems Inc. uses special ceramic composites that, when heated, releases ions beneficial for hair.

By using Arctic Freeze to replace lost refrigerant and oil in an automotive air conditioning system, NASA-derived QwikBoost chemistry provides colder air up to 50% faster than a conventional R-134a refrigerant product. Compared to operating with only PAG-oil (a lubricant), the addition of QwikBoost reduces wear and tear on the system by lowering compressor temperatures and extending the useful life of the lubricant. An entire range of Arctic Freeze products is now available for use in ground vehicles.

Nanomaterials, Cleaning and Hair-Styling

In the last two decades, a lot of work has been done in the field of nanomaterials, which have found several modern applications. These objects and materials are about 10,000 times thinner than a human hair.

One of the applications is as microcapsules, of the size of the blood cell, that are used in injecting cancer-fighting drugs into solid tumors deep inside the body. Originally microcapsules were made in low-Earth orbit where membranes could easily form due to the absence of gravity. Special ceramic nanoparticles containing a unique mixture of metal oxides can be used to build the surface of the microcapsule.

When these capsules are heated by a magnetic field such as Magnetic Resonance Imaging (MRI) diagnostic device, they release the contents of the microcapsule. The heat melts the particles creating holes in the microcapsule, which releases the drug from the capsule. This phenomenon can be controlled and has proven very effective in controlling the medicine intake.

Inspired from this use of metallic ceramic composites, Farouk Shami, the founder of Farouk Systems Inc., developed a unique ceramic composite and incorporated it in its hairstyling iron (CHI®). These ceramics, when heated at low temperatures—roughly 180 to 200 °C – released ions that proved beneficial for hairstyling. According to the company, the ions help to smooth and soften the hair, thus making it easier to manage and style.

Typical cleaning compounds such as chlorine and alcohol produce fumes that can be harmful in the contained environment of an aircraft. Therefore, scientists tried to come up with alternative methods to keep surfaces clean and disinfected. One of these methods involved the use of nanosilver particles. Because nanosilver acts as a passive sterilizing component, it essentially created tools with self-disinfecting surfaces. Airborne microbes like fungi and bacteria died after they settled on the surface.

Global Positioning System (GPS)

One of the first and most important things to know precisely while in space is the spacecraft location with respect to other bodies in space such as Earth, Moon, Sun, an asteroid or other satellite. NASA developed advanced technologies as part of the space program, giving high precision location of the spacecraft and astronauts so that their moves can be determined accurately.

NASA's Jet Propulsion Laboratory (JPL) developed GYPSY-OASIS software or GNSS Inferred Positioning System and Orbit Analysis Simulation Software used to process and calculate data to

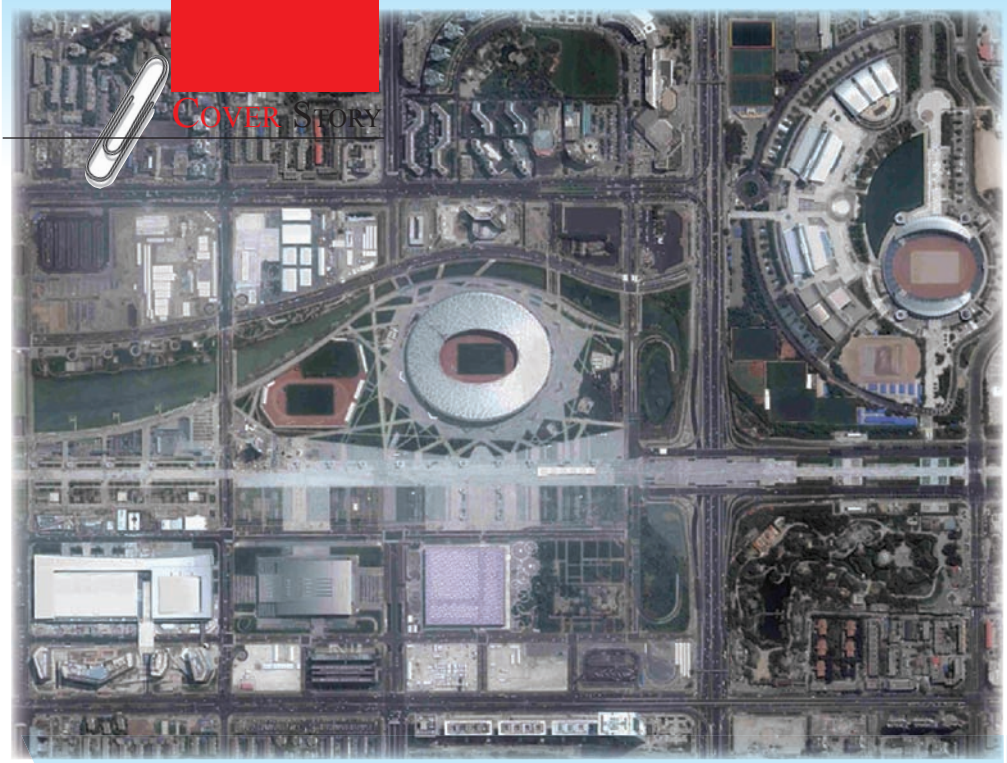
SPINOFFS GALORE!

• Invisible teeth braces hit the market in 1987. These are made of translucent polycrystalline alumina (TPA). This was first developed by a company called Ceradyne developed TPA in conjunction with NASA Advanced Ceramics Research to protect the infrared antennae of heat-seeking missile trackers.

• To increase the comfort of astronauts on the Interna&onal Space Sta&on, space underwear has been developed with excellent properties: deodoriza&on, an&-bacterial properties, heat reten&on, an&sta&c properties, functional mobility and comfort. MAXIFRESH PLUS (MXP) garments have been created with this technology to be worn in daily life on the ground. MXP material can greatly reduce the smell of perspira&on and aging odor (a specific odor that increases as people age). This underwear cuts the smell of perspira&on by 92% and aging odor by 82%. The material can absorb a great quan&ty of perspira&on, so it is also recommended for mountain climbing.

• Based on the insula&on material technology that is used for the fairings that protect a satellite during launch, GAINA is a light, thin insula&on material with high durability against heat, thermal shock and shock loading, and in hot environments. With these high-insula&on properties, it has been used for a wide variety of purposes, such as housing. Poten&ally, it could become a new material that will contribute to global warming preven&on.

• To clean water and to keep it clean for longer periods of &me, NASA came up with a filter technology that used specially activated charcoal containing silver ions that neutralize pathogens in the water. Along with killing bacteria in the water, the filters also prevent further bacterial growth. Companies have borrowed from this same technology to bring us the water filter systems millions of people use at home every day.



The Olympic Green in Beijing, China is seen in this satellite image collected by DigitalGlobe Inc. on 25 May 2008 and released to Reuters. The National Stadium (center), also known as the Bird's Nest, the National Aquatics Centre (lower center), also known as the Water Cube, and the Olympic Sports Center Stadium (top right) are seen.
(http://www.boston.com/bigpicture/2008/07/beijing_2008_preparations_thre.html)

determine a spacecraft's position. A companion software package called Real-Time GIPSY (RTG) was developed to provide positioning in certain time-critical applications.

In 2004, the precision GPS software was inducted into the Space Foundation's Space Technology Hall of Fame. Hundreds of commercial and non-commercial licenses for GIPSY and RTG have been released including more than 200 science and non-profit user licenses of GIPSY on a no-fee research basis.

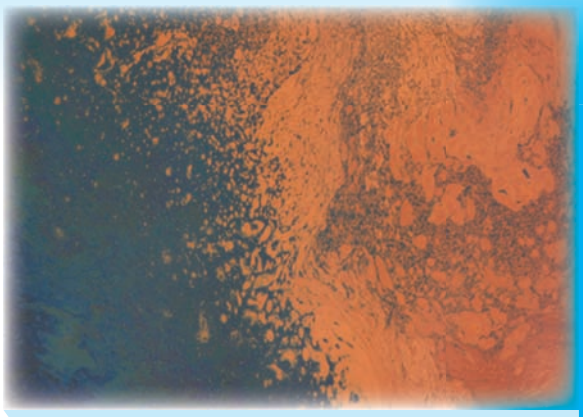
One of the commercial organizations licensing GIPSY is DigitalGlobe. DigitalGlobe's satellites take pictures of the Earth's surface. In order to place pictures accurately on a map, DigitalGlobe must know the location of the satellite when it shoots pictures of Earth, as well as the satellite's direction when it took the picture. By combining this information, DigitalGlobe can assemble the pictures accurately to create high-resolution imagery of the Earth. It supplies imagery for a variety of uses within defense and intelligence, surveillance purposes, civil applications, mapping and analysis, environmental monitoring, oil and gas exploration, infrastructure management and navigation technology.

Another major client of DigitalGlobe is Google®, a provider of Internet search tools and services. Google uses the imagery for its Google Earth and Google Maps applications, providing a base layer of satellite imagery that Google can overlay information on, such as roads, residences, and businesses. With Google Maps, users enter a single address or a starting and ending address, and then have the option to view the location or route with or without satellite pictures. If users choose the satellite view, they can see landmarks and other points of interest along the way. With Google Earth®, users can enter an address and view the satellite imagery of that specific location.

For a similar mapping platform, DigitalGlobe supplies imagery to Bing, an Internet search provider of Microsoft®. The news media are another frequent user of DigitalGlobe's satellite imagery to provide a bird's eye view of a newsworthy location. Cellular phone companies use this technology in the current smartphones. Insurance companies also purchase DigitalGlobe's satellite imagery to get a distant look at damage resulting from natural disasters like hurricanes and floods, without having to visit the location.

Oil-consuming Bacteria

One of the biggest environmental disasters of recent times happened on 20 April 2010 when a deep-water oil spill occurred due to the explosion in an oil well near the



Oil slick over the Gulf of Mexico waters.
Source: John Keesler, University of Rochester, NY

Gulf of Mexico. The oil well was owned by BP and operated by Transocean under contract with BP. The leakage lasted for 87 days and nearly 4.9 million barrel crude oil leaked into the ocean. This was followed by a humungous task of cleaning the water to save marine life and bring it back to its natural balance.

One of the methods that played an important role in cleaning the waters was the use of bacteria that can consume oil and thus separate oil from water. This research also owes its origin to the space community.

There is limited supply of essentials such as air, water and energy in space and they must be carefully managed and optimized for use. Resources need to be recycled and reused to maximize their life. One of the methods they looked at, even before building up ISS (International Space Station), involved using the Earth's most abundant biological resource: bacteria.

Researchers found that carefully using the right mix of bacteria can break down the toughest organic compounds, otherwise difficult to degrade, into subunits like carbon dioxide and water. They produce protein enzymes that accelerate the breakdown process.

Companies have also developed water purifiers based on photosynthetic microorganisms that can sustain in presence of small amount of sunlight. These purifiers are used by astronauts in space and can operate for very long periods of time, particularly useful in inter-planetary missions. This important discovery soon found its way into various industrial applications. These products can be used to treat animal waste, clean municipal lagoons, wastewater systems and septic tanks. Several companies use this method to reduce the environmental impact of their waste products.

Honda Insight: Electric hybrid vehicle

A 1926 Bentley. *Source: Wikipedia*

Rounding the vertical corners on the front and rear of the cab reduced drag by 40% while decreasing internal volume by only 1.3%.

Paraffins and Asphaltenes, components of crude oil, can settle out and create deposits that can bring oil production to a standstill and require costly maintenance treatments to remove. Strains of bacteria break down those deposits, leading to significant boost in productivity. The production of a Kansas oil well increased over 500 percent after treatment with these products.

A similar approach was used to remove oil from water during the BP oil spill disaster in 2010. Bacteria decomposed at least 2,00,000 tons of oil and natural gas from the Gulf of Mexico and cleared the water up to half a mile below the surface.

Hybrid Cars

There has been increasing hunt for alternate sources of energy in addition to figuring out ways to reduce the consumption of non-renewable fuel reserves such as fossil fuel. People have been developing ways to reduce the consumption of fossil fuel, like coal and petroleum products, which form the basis of several industries and transportation equipment till date. Fossil fuel not only powers the machinery but it also brings power to the nation that is rich in oil reserves.

More recently, renewable energy resources such as wind, solar and hydro-energy have significantly started contributing to the national energy requirements. One of the other major breakthroughs in reducing the oil consumption in automobile industry has been the development of hybrid vehicles and pure electric vehicles (EV). In hybrid vehicles, the engine works in conjunction with a rechargeable battery that increases the gas mileage by at least 50%. If everyone drives a hybrid vehicle, that would reduce the world gasoline consumption due to vehicles by nearly 35%.

Conventionally, each mechanical or electrical device is powered by one source: laptop powered by electricity, car powered by gasoline or diesel and railway engine powered by coal. But a spacecraft needs to be powered by multiple energy sources such as solid fuels, liquid fuels, fuel cells, batteries, photovoltaic panels, etc. All these sources work in tandem to ensure spacecraft operability during its mission. This idea became the basis for hybrid vehicle development where more than one energy source drives the vehicle.

A hybrid vehicle battery needs to store power for a longer time as compared to conventional battery. NASA Glen Research Center has long worked on starting new or mature technologies to develop optimal power systems to be used in space. Energy storage has also been a key issue in carving successful space missions.

Unlike normal batteries which store and discharge energy through chemical reactions (electrodes and electrolyte), super-capacitors store energy electrostatically. In this way, super-capacitors charge and release energy more quickly than a battery, and unlike a battery, can tolerate up to 1 million charge and discharge cycles without wearing out. Though there were certain disadvantages compared to batteries, such as low energy storage, super-capacitors presented an interesting candidate to couple with batteries or other power sources in space applications or in hybrid electric land vehicles.

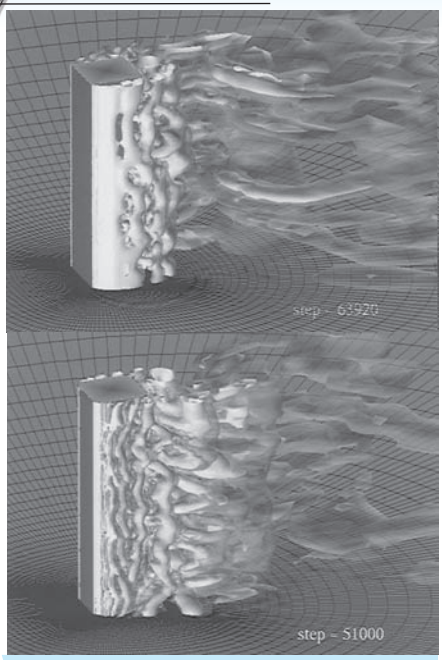
Another advanced concept is the development of a retrofit system for converting rear-wheel drive vehicles into gas/electric hybrids, installing an electric-assist motor and using super-capacitors instead of batteries. The electric motor can be inserted into the drive train of a standard, gas-powered vehicle to supply electrical-assist power to the internal combustion engine. Through monitoring multiple engine performance parameters, vehicle control strategically establishes the appropriate amounts of assist power to significantly enhance the vehicle's fuel economy. The system operates in the background, requiring no driver intervention or changes to typical driving habits.

There can be many commercial applications of this technology. Delivery vehicles such as post office vans, auto-rickshaws and taxis can be made hybrid substantially increasing the fuel economy. Almost all major car companies have released one or more hybrid models.

Aerodynamic Design

The external shape of products such as cars and trucks has changed a lot over time. For example, there has been significant change in the front end of cars including the hood and the windshield over the last 100 years. A vintage car from the 1930s (a 1926 Bentley shown in the picture above) looks very different in appearance as compared to the Honda Insight shown above.

It is not only aesthetics and people's



Vortices generated around the corners of the block: sharp corners (top) and rounded corners (above)
http://dx.doi.org/10.1016/S0167-6105(98)00048-8

Space Shuttle showing the shuttle and additional rockets (above left). *Source: Pratt & Whitney Rocketdyne* Prius 2013 *(bottom)*; Designline bus introduced in New York City public transport in 2007 (above right)

preference changing with time but these design changes are mostly based on principles of physics. A physical object placed in air feels a push in the direction of the flow. That is primarily due to the difference in aerodynamic pressure on the either sides of the object. This force (or drag) is proportional to the cross-sectional area of the object faced by the wind and the wind speed. During a windstorm, it is harder to stand but a person can bend or sit with less effort.

Vehicles with rectangular front use almost half of their engine power to overcome aerodynamic drag. The figure below shows the difference in the flow eddies behind a rectangular block with sharp corners (left) and rounded corners (right). It can be seen that the rounded corner body produces smaller eddies thus not developing large regions of low pressure as compared to the left picture.

NASA engineers at the Dryden Flight Research Center have worked long to reduce this drag and provide optimal design for space vehicles that require large amount of thrust to move against the Earth's gravitational force. Today's space shuttles with their launcher rockets have a nose designed to reduce the downward force or drag acting on the vehicle due to the atmosphere.

Other design modifications such as vortex generators to control flow separation on airfoils and hence drag reduction on airplanes and spacecrafts have been tested and implemented on road vehicles as well. The nose of the rocket is designed to reduce the drag and provide the streamline flow that is similar to several current cars. The generated vortices "energize" the slower-moving boundary layer and thereby reduce drag and, in aircraft applications, increase lift.

Subsequent studies in 1990 and 1991 continued vortex-generator research with an exploration of various active and passive methods for controlling two-dimensional separated flow. These studies quantified and characterized the behavior and performance of a variety of large-eddy breakup devices for turbulent flow separation control.

The modifications tried by the engineers at Dryden were adopted by truck manufacturers. In addition, the cargo boxes of most delivery trucks today have rounded corners and edges, a direct application of the research conducted at Dryden on the "shoebox."

Rounding the vertical corners on the front and rear of the cab reduced drag by 40% while decreasing internal volume by only 1.3%. Likewise, rounding the vertical and horizontal corners cut drag by 54%, with a 3% loss of internal volume. Closing the gap between the cab and the trailer realized a significant reduction in drag and 20 to 25 percent less fuel consumption. A second group of tests added a faired underbody and a boat tail, the latter feature resulting in drag reduction of about 15%. Assuming annual mileage of 1,60,000 driven by an independent trucker, these drag reductions would translate to fuel savings of as much as 25,000 liter per year.

Vehicles with rectangular front use almost half of their engine power to overcome aerodynamic drag.

There are several other technical advancements made as part of space research that found other applications. So, the next time you look at a space launch, remember that you are enjoying many of the technologies that were originally meant for space exploration.

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FEATURE ARTICLE

The Golden Mathematics of Life

SUJATHA T. PARVATHY

Although the beauty of nature cannot be contained or captured in a mathematical equation, the marvelous mathematics of nature has not only mesmerised scientists but also designers and artists.

The most beautiful thing we can experience is the mysterious. It is the source of all true art and science."

– Albert Einstein

LIFE, in its myriad forms, is fascinating. Even more fascinating are the processes by which an organism develops. A chain of orderly steps leads to the development of an organism from a single cell.

Just as laws and principles govern the world of physics and chemistry, the biological world too follows certain mathematical laws. The geometrical patterns seen in flowers, fruits, leaves and branches, the shape of mollusc shell and even the number of bones as well as shape of organs in humans interestingly follow a mathematical rule.

This number series that exists in most life forms is known as the Fibonacci series. The series is 0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89…., where each successive number is the sum of the two preceding or previous numbers. Each number in the series can be derived using the formula $Fn = F^{(n-1)} + F^{(n-2)}$.

The Fibonacci series was named after Fibonacci (pronounced as Fib-on-arch-ee meaning 'son of Bonacci', a name posthumously given to him), the great mathematician of the medieval Europe, born in Pisa (Italy) about 1175 AD. His full name was Leonardo Pisano.

Fibonacci discovered these magical numbers by analyzing the birth rate of rabbits and wrote in *Liber Abaci* or *Book of Abacus* in 1202: "Someone placed a pair of rabbits in a certain place, enclosed on all sides by a wall, to find out how many pairs will be born in the course of one year, it being assumed that every month a pair of rabbits produces another pair, and that rabbits begin to bear young, two months after their own birth."

He assumed that the rabbits do not escape and none die and there will be a pair of rabbits, one male and the other female at each birth. After one month, the pair of rabbit matures. After two months, Fibonacci found one adult pair and one juvenile pair. After three months, the count was 1 juvenile pair (original) and 2 adult pairs (one pair from the original and one from the adults of the first juvenile pair). After four months, there were 2 juvenile pairs and 3 adult pairs. By five months, the count was 3 and 5, a month later it was 5 and 8, then 8 and 13, 13 and 21, and so forth (Fig 1). Thus Fibonacci numbers were actually the solution to the problem of multiplication of a hypothetical population of rabbits.

The magical numbers not only did solve the puzzle of multiplication of rabbits but also threw light on the mysterious designs and patterns existing in nature. Fibonacci numbers appear quite often in the biological world. There are numerous examples in the plant kingdom. The numbers of petals

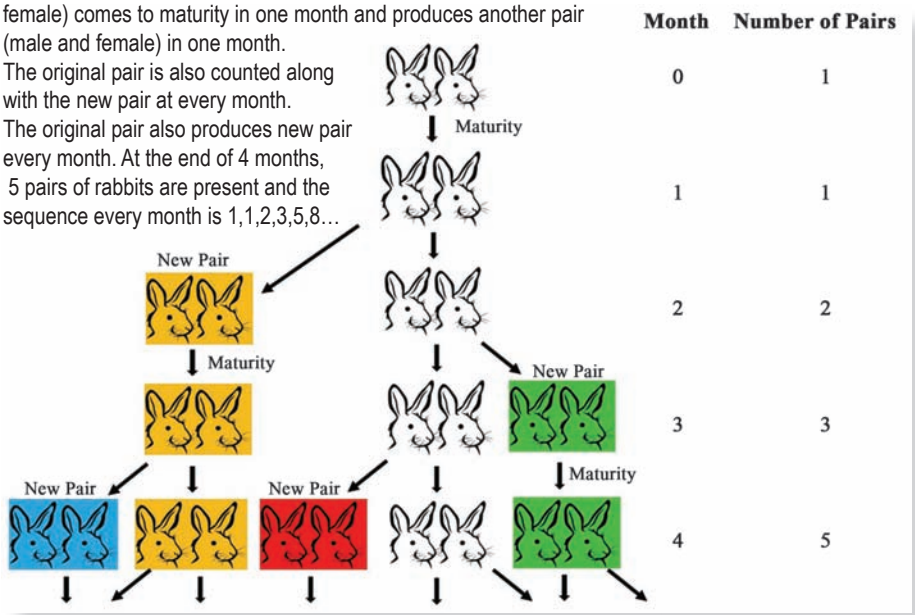

Fig 1. Fibonacci's Rabbit problem. Each pair of rabbit (male and female) comes to maturity in one month and produces another pair (male and female) in one month. The original pair is also counted along with the new pair at every month. The original pair also produces new pair every month. At the end of 4 months, 5 pairs of rabbits are present and the sequence every month is 1,1,2,3,5,8…

Picture courtesy: www.pbase.com/ken_ducker; en.; DOR Farm, Narkhoda

Fig 2. Fibonacci numbers in petal numbers of flowers. Flowers of Cala lily (one petal), Euphorbia sp (2 petals), Trillium (3 petals), Tabernaemontana sp (5 petals) are shown in the top panel and Tridax decumbens of Family compositae with 5 petals, wild species of sunflower with 8 and 13 petals respectively are shown in the bottom panel.

Complex patterns are formed by linkage of several pattern-forming reactions.

of flowers follow a Fibonacci series. Cala lily has a single petal, Euphorbia has 2 petals, lilies and Trillium have 3 petals, Geranium and some wild roses have 5, delphinium has 8, marigold has 13, daisies have 21, sunflower has 34 petals and so on. Wild species of sunflower of family Compositae have 8 and 13 petals (Fig 2). Daisies also have 21, 34, 55 and 89 petals. All these numbers are members of the Fibonacci series.

The arrangement of leaves on the stem is consistent with the Fibonacci numbers. In plants where leaves are arranged spirally around the stem, Fibonacci numbers occur while counting the turns and number of leaves, to reach a leaf occurring directly above the starting leaf. For example, to reach a leaf nearly above the first leaf, there are three rotations in the clockwise directions, passing 8 leaves. The first turn has 3 leaves, second rotation has 5 leaves and third rotation has 8 leaves. Therefore, the fifth rotation will cover 13 leaves. The number of turns in each direction and the number of leaves met are consecutive Fibonacci numbers (Fig 3).

When leaves are arranged around the twig in a spiral and a line is drawn from the point of attachment of leaf to the stem to the next leaf, the line forms a spiral around the stem. For reaching each adjacent leaf, the spiral rotates by a fraction of a full rotation which is the angle of winding. Alternate leaves will have an angle of 1/2 of a full rotation. The angle of rotation may be 1/3, 2/3, 3/8, 5/13, etc. The numerator and denominators are numbers of Fibonacci series and the denominator is usually the second successor of the numerator. The alternate arrangement of leaves can be described in terms of ranking, where the number of leaves is called rank. When 2 rotations cover 5 leaves, the ranking is 5 and in 3/8 rotations, where 3 rotations cover 8 leaves the ranking is 8.

Fig 3. Number of turns and leaves per turn is in fibonacci series. A. Three rotations are represented in the clockwise spiral and the leaf orginating in the spiral is marked as red. First leaf on top is numbered zero. 3 leaves are present in 1st rotation, 5 leaves in second and 8 leaves in 3rd rotation in a twig of Adenium sp. B. Hibiscus shoot showing fibonacci numbers. Leaves 13 and 16 are directly above and to reach 13th leaf, 3 leaves are crossed. Similarly, 9th and 12th leaf are directly above and 9th leaf is the 3rd from 12th leaf. 8th leaf is above 13th leaf and 5 leaves are crossed to reach 8th leaf from 13th leaf. 7th leaf is directly above 15th and 8 leaves are crossed to reach 7th leaf from 15th leaf.

Similarly, in sunflower, the arrangement of seeds on flower heads shows a pattern. There are two forms of spirals – the clockwise spiral and anticlockwise spiral. The number of the clockwise and anticlockwise spirals will be, interestingly, consecutive Fibonacci numbers 34 and 55 or 55 and 89, etc (Fig 4a). So also the spirals in the cauliflower or broccoli in each direction will be neighboring numbers of the Fibonacci series (Fig 4b). In pineapple also, the Fibonacci series is present in the fruit, 8 spirals in clockwise direction, 13 in anticlockwise direction and 21 in the near perpendicular direction (Fig 4c).

The Fibonacci sequence can also be seen in the way tree branches or splits. Two branches are produced in the main trunk after growth for a particular period. Then one of these stems branches into two, while the other remains dormant. For each new stem, this pattern is repeated. This pattern is therefore 1, 2, 3, 5 etc., the numbers in the Fibonacci series (Fig 5).

Golden Ratio

Golden ratio is the ratio of the adjacent numbers in the Fibonacci series. The Fibonacci sequence is: 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, 233, 377, 610, 987, etc. If a number in the Fibonacci series is divided by its immediate predecessor, for example, 21/13 or 89/55, the result is the golden ratio. Interestingly, the value of this ratio is another number approximately equal to 1.618, nicknamed as the "divine number".

Also known as 'divine proportion', 'golden mean' and 'golden section', the golden ratio is represented as Greek letter Phi Φ. The reciprocal of golden ratio is denoted by the small letter phi, φ, such

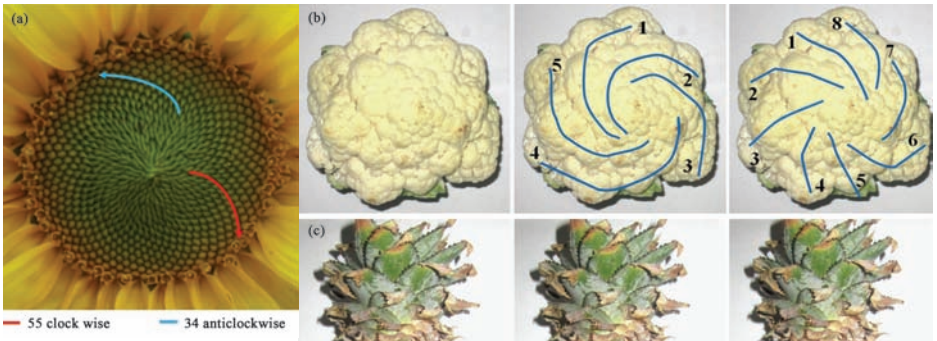

Fig 4. Fibonacci series in spirals of flowers and fruits. A. Spirals in Sunflower head showing 55 spirals (red) in clockwise and 34 spirals (blue) in anticlock wise direction (Image source: DOR farm, Narkhoda). B. Cauliflower head showing 5 spirals in clockwise and 8 spirals in anticlockwise direction. C. Pineapple shows spirals in 3 forms; 8 spirals in clockwise direction, 13 in anticlockwise direction and 21 in the near perpendicular direction.

It is fascinating to learn how the innate beauty of nature and the intricate designs and patterns of the natural world are determined by the intriguing number systems or Fibonacci series.

The marvelous mathematics of nature has not only mesmerised scientists but also designers and artists.

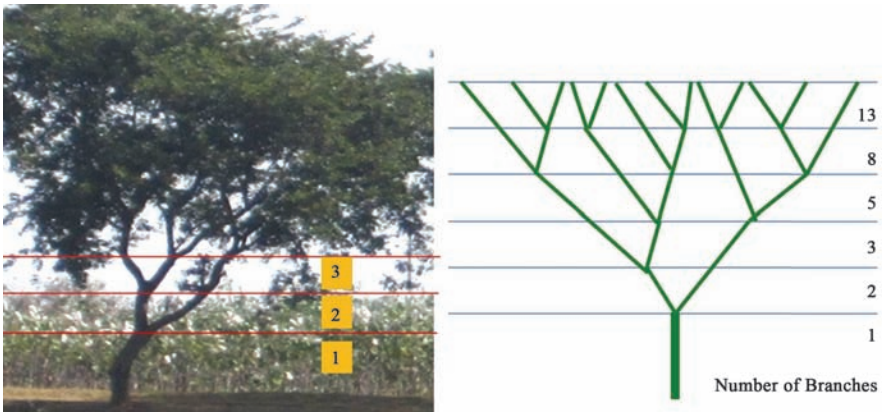

Fig 5. Branching pattern in trees. The main trunk grows and branches into two. One of the new branch, branches again while the other continues to grow for a while before branching. Tree showing branching till level 3 (Image source: DOR farm, Narkhoda). Diagrammatic representation of tree branching showing Fibonacci number of branches at each branching level. The horizontal lines represent each level of branching and numbers of branches are indicated on the horizontal lines.

that $\Phi = 1/\Phi = 0.618$. It is obtained when the fibonacci number is divided by its immediate successor such as 34/55 or 144/233.

The value of Phi approximates to 1.618 by 11th and by 15th fibonacci number and thereafter it is uniformly 1.618. Also the nth value of 'Phi' is 1 + ((n-2)th value of 'phi'). For example, the value of 'Phi' for 11th number (89/55), is 1.618181818 and value of 'phi' for 9th number (34/55), is 0.61818181818. The value of 'Phi' for 11th number is 1+ value of 'phi' for 9th number in the fibonacci series. The 9th and 11th numbers or ratios have 55 as common denominator, while the ratio of the numerators 89/34 is 2.6176450 which is 1.6182. This is applicable to all the numbers of the series.

The 12th fibonacci number, 144 is a perfect square which also happens to be 12 12. The 3rd, 4th, 5th and 6th numbers of Fibonacci sequence are 2, 3, 5 and 8 respectively. Interestingly all 3rd, 4th, 5th and 6th numbers in the Fibonacci series are multiples of 2, 3, 5 and 8 respectively. Every third number in the Fibonacci series such as 2, 8, 34, 144, etc. is in multiples of 2. Similarly, every fourth number such as 3, 21, 144, 987 is in multiples of three, every fifth number such as 5, 55, 610, 6765, etc. is in multiples of 5 and every sixth number such as 8,144, 2584, 46368, etc. in the Fibonacci series is in multiples of 8.

Adolf Zeising, a German psychologist, found that the golden ratio is a universal law operating in nature expressed in branching of stems and arrangement of veins in leaves. The divine proportion was found in the skeleton of animals, branching of nerves and even in the proportions of chemical compounds and structure of crystals.

Golden Angle

The angle subtended by the smaller arc of a circle, when the ratio of the smaller and the larger arc forming a circle are in golden ratio, is the golden angle. For example, if the circumference of the circle is a+b and 'a' is the length of the longer arc and 'b' is the length of the smaller arc and a and b are in golden ratio such that, a/b = and (a+b)/a = a/b, then the angle subtended by the smaller arc b, is the golden angle (Fig 6a).

The golden angle is seen in plant phyllotaxy or periodic leaf arrangement. Divergence angle is the angle formed between a line drawn from the stem to the leaf and a corresponding line for the next leaf and this is usually the golden angle. Phyllotactic ratio is the fraction of a circle through which a new leaf turns from the previous leaf. This value is usually 0.382

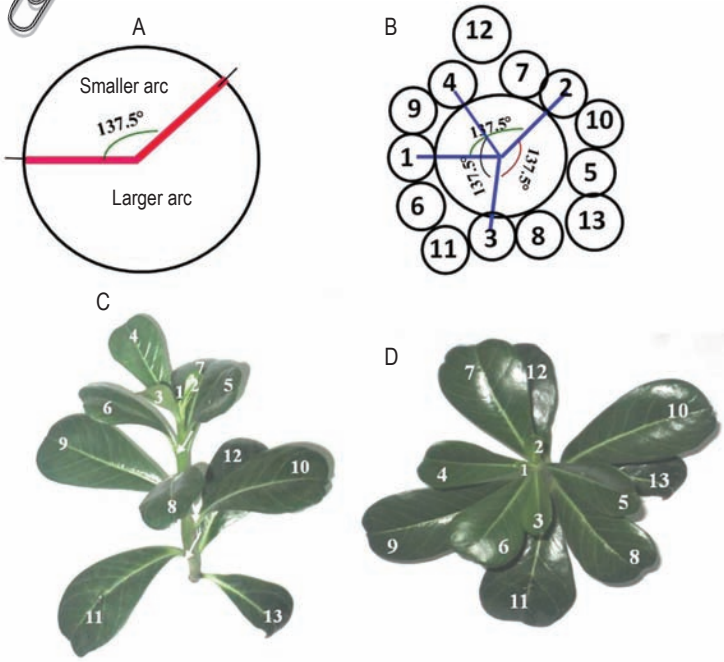

Fig 6. Golden angle in Phyllotaxis. A. The angle subtended by the smaller arc of a circle when the ratio of lengths of the larger to smaller arc (a/b) is Phi or 1.618.Golden angle is 0.382 turns or 137.5°. B. Spiral phyllotaxy at the meristematic region according to Hofmeister's rule. New primordial (small circles) are formed around the circular meristem (large circle) at 137.5° apart from each other forming spiral. Hofmeister's rule of primordial development results in spiral phyllotaxis. Lateral view (C) and top view (D) of a twig of Adenium sp showing spiral phyllotaxis.

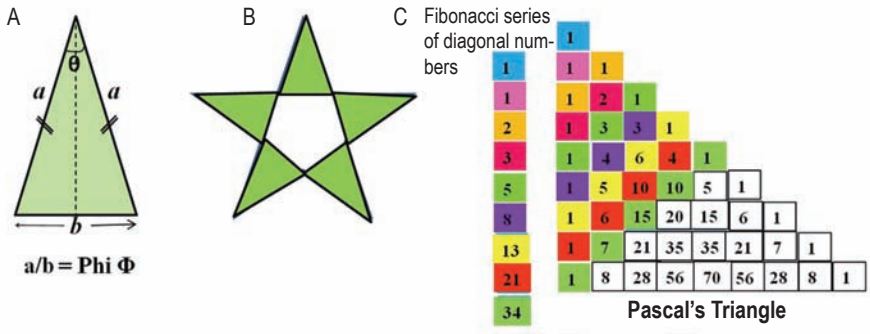

Fig 7. Golden triangle and Fibonacci numbers. A. Golden triangle with the ratio of the length of side to base in golden ratio. B. A pentagram formed by five golden triangles. C. Pascal's triangle showing the sum of diagonal numbers forming the Fibonacci series.

or 1/ 2 and is known as golden turn.

The golden ratio based arrangement provides maximum packing of seeds in a given space. Also the closely packed points in the spirals of the sunflower head and fruits of pineapple are separated by the golden angle of 137.5 degrees in tight spirals.

In 1868, Wilheim Hofmeister reported a microscopic study on meristems which show spiral phyllotaxis. He suggested that new primordia are formed in the meristem (growing tip of the plant) at the least crowded spot. Primordia initiate one at a time along the circular meristem and are radially displaced away from the centre as they grow. As the number of primordia increases, the divergence angle of successive primordia converges to the golden angle value of 137.5 degrees which in turn results in Fibonacci series of spirals in the meristem. Organs are initiated at about 137.5 apart forming continuous spiral (Fig 6b).

Golden Triangle

Golden triangle is an isosceles triangle (two sides equal) where the ratio of side to the base (a/b) is in golden ratio (Fig 7a). A pentagram can be formed with five golden triangles (Fig 7b). In maths, the Pascal's triangle is formed by number series such that each number is formed by the sum of numbers immediately above it. It is amusing to note that the numbers in the diagonals of Pascal's triangle add to Fibonacci numbers (Fig 7c). Sum of diagonal numbers such as (1+1), (2+1), (1+3+1), (3+4+1), etc. are 2, 3, 5, 8…,

The Fibonacci sequence can also be seen in the way tree branches or splits. Two branches are produced in the main trunk after growth for a particular period.

forming the Fibonacci series.

Golden Square or Rectangle & Golden Spiral

The Fibonacci numbers are 1,1,2,3,5,8,13,21,34… For example, to start with, two squares of 1 unit placed adjacent to each other give a rectangle of length 2 units and breadth of 1 unit. Another square of size 2 units is placed above the rectangle of 2 units (formed by 2 small squares of 1 unit), to form new rectangle of length 3 units and breadth 2 units. The squares with sides of Fibonacci numbers are golden squares and the rectangles whose sides are two successive Fibonacci numbers are golden rectangles (Fig 8a).

When a spiral starts from the square of side 1 unit and covers all the squares (used for construction of Fibonacci rectangles), such that a quarter of the circle is in each square, the result is a spiral pattern which is seen in most biological organisms (Fig 8b). Sides of consecutive squares have length equal to adjacent numbers of Fibonacci series (Fig 8c). The spiral increases by a factor of the golden ratio. So points on the spiral are 1.618 times as far from the centre, after a quarter-turn.

If a line is drawn from the centre of the spiral and two points of the spiral cross that line, the length of the line cutting the second point will be 1.618 times the length of the line cutting the first point of the spiral. This may be true for spirals farther from the centre in structures with many spirals, as the golden ratio approximates to 1.618 from the 11th number of the Fibonacci series.

Such spirals are seen in the shape of shells of snails, sea shells and in the arrangement of seeds on flower-heads. In Nautilus and snail shells, the shell is a spiral curve and as the animal grows internal chambers are added which

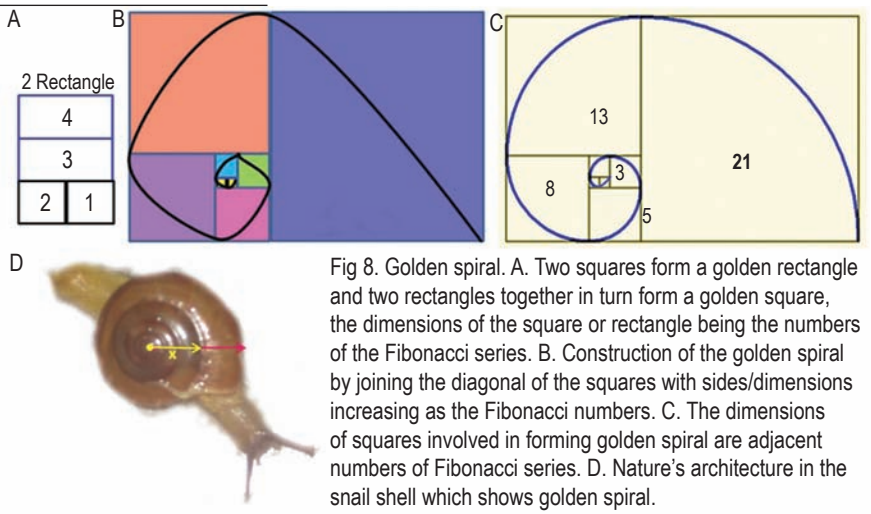

Fig 8. Golden spiral. A. Two squares form a golden rectangle and two rectangles together in turn form a golden square, the dimensions of the square or rectangle being the numbers of the Fibonacci series. B. Construction of the golden spiral by joining the diagonal of the squares with sides/dimensions increasing as the Fibonacci numbers. C. The dimensions of squares involved in forming golden spiral are adjacent numbers of Fibonacci series. D. Nature's architecture in the snail shell which shows golden spiral.

provide buoyancy in water. In one turn, the shell grows by a factor of golden ratio or 1.618 (Fig 8d).

Universality of Golden Law of Nature

Structural patterns not necessarily based on Fibonacci pattern are seen in sand dunes, river gullies, patterns in skin coat of animals, branching pattern in neurons, etc. The shape and amazing natural designs or patterns form an innate and distinct quality or identity of the object.

The human body is structured or designed on the Fibonacci pattern. We have 2 hands with 5 fingers and each finger has 3 bones, all numbers being the members of Fibonacci series. The ratio of the length of body from navel to floor/ feet and navel to the top of head may be surprisingly in the golden ratio. So also is the case with fingers in the human hand.

The shape of the human ear (pinnae) is related to golden spiral. A face is perceived as more attractive when the proportion closely adheres to the golden ratio Phi. In bee colonies, sterile female worker bees outnumber the males or drones. The sex ratio of female to male honeybees is not 1:1, but will be approximately 1.618. Amazing isn't it?

The universal law of golden ratio operates at the molecular level as well. The length of DNA molecule is 34 angstroms (1 Angstrom= 1-10 m), while the width is nearly 21 angstroms (20-21Angstroms) in a single turn of double helix consisting of 10 base pairs. Again, 34 and 21 are members of the Fibonacci series and the ratio of these numbers is nearly the golden ratio.

A set of three nucleotides in DNA codes for an amino acid and is termed as codon (64 codons form the genetic code). Jean-Claude Perez, a French scientist has described the mathematical pattern in DNA as important in the self-structuring or self-organisation of genes and genomes. He described this in his books "l'ADN decrypté" (DNA deciphered) in 1997 and "CODEX Biogenesis: Les 13 codes De L'AND" (The 13 codes of DNA) in 2009.

Analysis of the relative proportion of ACTG nucleotides in HIV genome shows Fibonacci numbers revealing a "DNA supra code". For example, 144 contiguous TCAG nucleotides have exactly 55 T nucleotides and 89 A or C or G nucleotides. Fractal is a complex pattern produced from the duplication of simple shape following a fixed set of rules. The codon population in single-stranded DNA of human genome is fractal and governed by the golden ratio.

Hurricanes, cyclones and galaxies have a shape similar to a mathematical curve or a logarithmic spiral. The spiral grows in a geometric way with increasing distance from the center similar to the spirals in the biological world. Golden ratios extend from mathematics to the theory of music, fine arts and architecture and found from Leonardo da Vinci's paintings to modern art, to photography, from the ancient Greek temple architecture to modern constructions, and from the octave note in music to Beethoven's fifth symphony.

What more? It's amusing to know that Phi governs human behavior as well. A study by psychologist Vladimir Lefebyre (1992) demonstrated that humans exhibit positive and negative evaluation of opinions with 61.8% positive and 38.2% negative and the ratio of the positive to negative decisions tends to be the golden ratio.

The Phi and Fibonacci series have applications in prediction of stock market moves as reported by Stephen Wolfram, renowned scientist who worked on cellular automata (underlying rules that determine seemingly random phenomenon). His work featured in Forbes ASAP magazine stated, "This seashell may hold the secret of stock market behavior, computers that think and the future of science."

Why Golden Ratio?

Ever thought why nature has a numbering system, a specific geometry, art or architecture? The golden ratio and angle is seen in inanimate objects as well. It is believed that the ratio confers the most pleasing and beautiful shape.

Evolution has chosen the Fibonacci pattern for the most efficient harvest of sunlight by leaves for photosynthesis. In a forest, where plants and each branch or leaf in a plant competes for sunlight, the arrangement of leaves and branches following the Fibonacci series or golden angle avoids the shading effect of the leaves or branches on another. No two leaves follow the same radial line from centre to edge. Also by following the Fibonacci numbers and the golden ratio in the natural designs, maximum efficient packing of flowers or seeds is ensured as in sunflower heads or cones of pines or fruits of pineapple.

Many scientific explanations have been provided for understanding the mechanism of this amazing diversity in natural pattern formation as seen in animal coats. A multi-cellular organism develops from a single-celled zygote by repeated divisions and differentiation. During differentiation and pattern formation, cells lose their homogenous state even though they are identical in the genetic information contained.

The spontaneous processes generating the pattern formation was explained with the Activation-Diffusion model proposed by Alan Turing in 1952. According to this model, during embryonic development, the reaction and diffusion between molecules known as morphogens lead to breaking of symmetry

Fig 9. Fibonacci and the logo of Fibonacci Association

He assumed that the rabbits do not escape and none die and there will be a pair of rabbits, one male and the other female at each birth.

of homogenous state (Turing bifurcation or spatial instability) leading to unique textures on animal skin. But morphogens had not been found in biological systems.

Alfred Gierer and Hans Meinhardt (1972) also developed a model for pattern formation. They proposed that an activator regulates production of an inhibitor. Activator stimulates its own production (autocatalysis), diffuses to the neighboring cells and acts at short range. Inhibitor is antagonist of activator and acts at a long range. The activator and inhibitor molecules diffuse at different rates, inhibitor diffusing faster than activator. Pattern formation occurs by local autocatalysis and long-range inhibition. Inhibition can be due to depletion of the activator molecules as well.

Complex patterns are formed by linkage of several pattern-forming reactions. New coordinate systems are generated for sub-patterns. For example, limbs are formed in a pattern from the main body of the organism and formation of digits in limbs is a sub-pattern. During development, many structures are formed close to each other in a precise arrangement. This occurs when one structure activates the other on long range but excludes it locally resulting in a controlled neighborhood of structures. Minute external signals govern pattern formation processes which allow dynamic adaptation to changing conditions.

The theories put forth for pattern formation can be extended to explain why nature follows the numbering system. The Fibonacci series results when the preceding numbers are added. During development also cells arise from the pre-existing cells.

In plants a particular structure gives rise to a new structure following a production rule as described by D'Arcy Wentworth Thompson in 1917. If 'a' gives rise to 'b' and 'b' gives rise to 'c' and 'd', 'd' gives rise to 'e'and 'f', as per production rules 1, 2 and 3, then following production rules 1, 2 and 3 'a' will give rise to 'c', 'e' and 'f'. The summation of the previous processes at the micro or cellular or molecular level may result in the growth by logarithmic scale as observed in nature.

Computer simulations and mathematical modeling can be used to predict the biological processes involved in pattern formation/numbering systems. Pattern formation is periodicity in shape, while Fibonacci numbers is the definite periodicity in structures such as leaves, branches, etc. In plants the auxin, cytokinins or other growth hormones, their gradient in the meristem, the interaction of growth hormones, etc. play a major role in determining the position and identity of the new organ developed. External signals during a particular period play a significant role in determining the position and number of organs formed.

Gene activation or regulation in a spatial and temporal manner also is necessary for pattern formation. Whether genome is also structured based on the Fibonacci numbering system and the golden ratio and its possible role in the gene or protein functions is a subject of in-depth study.

Associations and Publications

The 'Fibonacci Association' was formed in 1963 with a prime focus on the magical numbers of Fibonacci series and study of integers with special properties. The logo of the association is a pentagram formed by 5 golden triangles (Fig 9).

The association is supported technically by the Canadian Mathematical Society and Department of Mathematics and Statistics of Dalhousie University. The 'Fibonacci Quarterly' is the official publication of the association which aims to generate world-wide interest in the Fibonacci mathematics. In addition, several books and tables are published by the association. The Fibonacci association also holds international conferences every two years for creating a common platform for discussion of maths and science, the applications of Fibonacci sequence as well as other special number sequences. The 16th International Conference was held at Rochester, New York from July 20-26, 2014.

The marvelous mathematics of nature has not only mesmerised scientists but also designers and artists. The alphabet, grammar and structure of even the genetic language seem to follow mathematical functions and equations. Can we consider the Fibonacci series and the golden ratio as another universal law of the biological world or law of beauty or is it a mere coincidence?

The beauty of nature obviously cannot be contained or captured in a mathematical equation. As in the words of the famous Canadian mathematician Coxeter, rather than a law of nature, the Fibonacci series are "only a fascinatingly prevalent tendency". It is fascinating to learn how the innate beauty of nature and the intricate designs and patterns of the natural world are determined by the intriguing number systems or Fibonacci series. The mysterious number games of nature have drafted and framed the fierce symmetry in the world around us.

August 5th of the year 2013 (05-08-2013) was a Fibonacci day. Mathematics is everywhere! There is no running away!

(Use of wild and cultivated species of sunflower respectively of Dr. A.J. Prabhakaran, Principal Scientist and Dr. Mangesh Y. Dudhe, Scientist, DOR in the study is duly acknowledged.)

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SHORT FEATURE

The Tea Diaries

A. SOUMYA RAO

WAKING up with a hot cup of tea is indeed princely; but to be woken up in the early morning in the middle of a sweet dreamy sleep, hustled up to run an errand to purchase tea leaves is cruel. That's the cruelty I had to endure today morning, when my loving mother, in the zeal to watch her favourite tearjerker soap opera yesterday night forgot to replenish tea in time.

If it was just me, it would have been easy to counsel with firm voice "No chai today; drink milk and keep your mouth shut"; but obviously not my father. Without his customary, not one but two cups of piping hot aroma-effusing chai as soon as he wakes up, he cannot move from his bed or finish the 'big job'. He has to be given his tea or else...No option but to rush to the shop and get the tea before he woke up.

I hurried to the shop at the end of our street. Ram kaka's shop is open even before the sun is up. Perhaps he knows that mothers have such pressing needs early in the morning quite often. Beaming cheerfully, he handed me our brand of tea packet even before I had the chance to open my mouth. May be the fond twinkling in his eye or the rustic slang he used triggered memories.

I suddenly recalled my high school teacher, Master Sisugoswami. One day in all earnest he persuaded us to appreciate the toil of multitudes that provides us our humble morning tea. He said "hard labour and toil of many are hidden unseen in every cup of tea that you drink. Do you know how strenuous it is to pluck the tea leaves, one by one, in the hot sun? How much hard labour goes in to curing the fresh leaves into tea that you can savour? Have you ever wondered about the living condition of the milkman, whether their children study or are they forced to do menial labour?"

He was an idealist who wanted to see the world as just and equal. Perhaps not a man for these times, or is he?

Tea, an aromatic beverage, is prepared by pouring hot or boiling water over cured leaves of tea plants *Camellia sinensis*. A legend credits 10th century Emperor of China, Shennong with the discovery of tea. The story goes that he asked his courtiers to boil water before drinking to avoid illness. The Emperor was taking his usual morning stroll in the garden when he saw a cauldron with a light brown liquid. Apparently some leaves from a nearby tea tree had fallen into it. The liquid caught the Emperor's attention and he decided to drink it. He was taken by the aroma and taste of this concoction and decided to make more of the liquid. Thus was born the beverage, which is today popular all over the world.

Another account says Bodhidharma accidentally fell asleep after meditating continuously in front of a wall, and on waking up, he seethes with rage and cuts his eyelids which fall to the ground and grow into tea bushes.

Though not much into myths myself, I will tell you about my friend "Captain" who would remark that there are still silly people who think the Earth is just 6000 years old regardless of the progress of science. So the real story we are yet to know.

Tea, tee, teh, thea, theneer, teo, the', tee-soppu, chya, sha, herbata, chai – the list goes on. The origin of the word tea could be traced back to 'Te' in Amoy language spoken in Fujican province and Taiwan and 'Cha' is derived from Cantonese in Guangzhou.

It was smuggled out of China by the British who sent spies to China during the ensuing gunpowder and tobacco wars. The British forced Indian farmers to grow opium and bartered the intoxicant with the Chinese for tea. A fierce war ensued following which the British realized they needed another source of tea. Tea then came to be planted in the Assam plains from which we derive the Clonal Assam tea *(Camellia sinensis assamica)*. Whether it is the Clonal Assam, Bergamot (Earl Grey), the Oolong served in Yixing purple clay teapots (it gets better at every sip, I assure you!), or the jasmine, lemon/ lemon masala (it's intoxicating indeed!) and of course the green and black tea – the variants are mindboggling.

Needless to say, more tea is consumed all over the world than coffee, chocolate, soft drink and alcohol combined, next only to water! Be it Britain, Japan, China, Arabia, UK or anywhere, tea has been

Myanmar has tea pickles called Laphet while Tibetans have buttery salty tea with butter of Yak's milk.

the symbol of social gathering, cultural heritage and status. It is universal and eliminates the difference between the rich and poor. Catherine of Braganza perhaps initiated the royal evening tea-session and the Japanese ceremonial tea is a tradition that goes far back in history.

If India and Pakistan are divided by a boundary, the pleasant Kashmiri Noon Chai, with its pink tinge, milky flavour with pistachios and cardamom unites people. Ireland, the highest per capita consumer of tea, has its famous Lyon's and Barry's tea outlets.

Britain serves cream tea that is named for the scones, clotted cream and jam served with it. Legend has it that when tea was introduced to England, drinking it became a status cult. The wealthy decided to add milk and cream to it.

Myanmar has tea pickles called Laphet – a delicacy eaten with roasted sesame seeds, crispy fried beans, peanuts and fried garlic chips. Tibetans have buttery salty tea with butter of Yak's milk.

But read my lips, nothing matches the consistency and excellence of Indian masala chai served with crispy hot pakodas on a pleasant rainy day. In fact, India is the largest producer and consumer of black tea in the world. According to ORG-India Tea Consumption Study, 83 percent households in India consume tea, which is the cheapest beverage in the world after water.

Tea is well known and ultimate for its Umami taste: combination of sweet, sour, bitter and salty. To explore the unique characteristic of tea, let's go a bit scientific. Chemists and biologists have fathomed a variety of chromosomal differences, lots of polyploidy of tea strains. Thus, we derive the unique flavours and aromas of tea. Tea has catechin, antioxidants, flavonoids, aminoacids, vitamins, and several polysaccharides.

To top that, it has theopylline and caffeine that alerts our senses in the morning.

The widespread and universal popularity of green and black tea is on the account of their ability to protect against cardiovascular disease and other health benefits. Consumption of green tea has gone up, as the hyped urban media promotes it as a slimming agent. Who wouldn't agree to lose an inch off their tummies, if all that they had to slog is but sip green tea. On a serious note, scientists have found that tea kills potent harmful viruses such as herpes virus simplex 1, 2 and T1 virus within a few minutes in laboratory animal tests.

Globalisation and the emergence of the nouveau-rich class has spurred the emergence of coffee outlets – where anything can happen over a cup of coffee, if you are ready to pay through your nose. But for money-starved college students it is the 'chai-sutta' ritual. From office-goers dropping by tea-stalls to escape from hectic work and equally hectic bosses, the security guards relaxing on the small glass after their shifts are over, teachers on tiffin breaks, old men in groups, bantering over how their daughters-in-law and wife always give them bitter tea with no sweeteners, it is the tea stalls that provide refuge.

The humble tea doesn't burn holes in the pocket. Train stations are filled with chaiwallahs screaming at the top of their voice and offering endless cups of steaming hot tea to weary travellers.

Tea almost became our national drink; perhaps it may soon. The former Deputy Chairman of the Planning Commission, Montek Singh Ahluwalia was inclined to declare tea as the National Drink in April 2013.

Walking with these trains of thoughts, as I neared my home, my favourite aroma, sweet, familiar, unmistakable, wafted and enveloped me. Apparently, it turns out that mother had opened another rather expensive pack of Darjeeling tea set aside as a gift for a colleague of father's, fearing that I would be late and father would wake up.

I'm used to fights between the two over the smallest of things and could sense the portent of things to come. I quietly grabbed my ebullient hot tea mug and rushed out to the veranda relishing every sip as a tribute to all tea-lovers out there.

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Einstein's Refrigerator

DHRUBAJYOTI CHATTOPADHYAY

Einstein and Szilard

The idea that had been gathering dust for 70 years was resurrected recently when Andy Delano started research into Albert Einstein's work and produced some chilling results.

WE know Albert Einstein as a theoretical physicist, whose name is synonymous with the Theory of relativity, $E=mc^2$, Photoelectric emission, Brownian motion, and so on. There is a story about Einstein that once he was asked by a reporter why he has not been associated with a famous research lab. In reply Einstein pulled out his notebook and said, "With this, my pencil and my brain, I have all the laboratory I need."

The reply shows his keen interest in theoretical physics, but how many of us know that he also worked on many more everyday tasks, like developing an energy-efficient refrigerator. Let's go down the bylanes of history and take a look at this story.

History behind Einstein's Refrigerator

In 1921, Einstein was awarded the Nobel Prize in Physics for his explanation of the photoelectric effect. From 1926 to 1933 Einstein and Leo Szilard, considered by many to be the father of the nuclear age, dedicated themselves to improving home refrigeration technology. So, why did a man with a Nobel Prize, worldwide fame, and genius intellect waste his valuable time working on such a mundane project like refrigerators.

For Einstein this was a very important project. According to most accounts, while Einstein was in Germany one day in the early 1920s he came across a newspaper article that described the death of an entire family – mother, father, and their children. Apparently, they had been killed in their sleep by a poisonous coolant that had leaked out of their refrigerator.

All of the coolants available in those days of refrigeration (ammonia, sulfur dioxide, and methyl chloride) were very toxic and would kill if they leaked out into the home. People were afraid to use a refrigerator. Einstein knew that there had to be a better way. So he took that challenge.

Szilard was just starting his career at that time. These two great scientific minds came together and concluded that the problem with refrigeration was not just limited to the poisonous coolant. The mechanical parts of the refrigerators were the real culprit. Anyone with even the slightest mechanical experience knows that moving parts cause wear and tear on any system. Eliminate the moving parts and the system will probably never leak.

As great physicists, these two men realized that they could use their knowledge of thermodynamics to produce a cooling system that did not involve any type of mechanical motion. And finally, they came up with a refrigerator without any moving parts, which was a unique piece of work.

Now let's see how a refrigerator works. The main principle behind a refrigerator is based on the second law of thermodynamics according to which without any external work heat cannot flow from a lower temperature to a higher temperature. Here refrigeration cycle is the reverse of the Carnot cycle. Carnot cycle is the heat engine which takes heat from higher temperature (source), converts some portion of this heat to work and releases the rest to the sink. Refrigeration cycle is also a heat engine which takes the heat from a lower temperature (source) to higher temperatures (sink) and for this external work is required.

On the basis of this external work, refrigerator system is of two types – Vapor Compression Type and Vapor Absorption Type.

In compression type the input energy is electricity and the energy consuming element is the compressor. On the other hand, in the absorption type refrigerator the input energy is low-grade energy like heat. Here compressor is absent, a pump acts as the energy-consuming element.

In both cases two types of working pressure are being created. In the evaporator the pressure becomes very low, as a result liquid transforms to gas by absorbing latent heat which creates the refrigeration effect. When it moves to the compressor the pressure increases and the gas loses heat to its surroundings and becomes liquid. This liquid comes again to the expansion device through the throttle valve. In this way it works in a cyclic order. This is the working principle of a refrigerator.

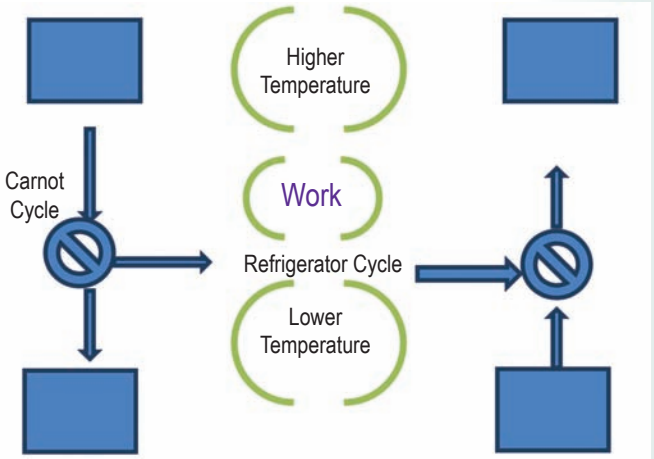
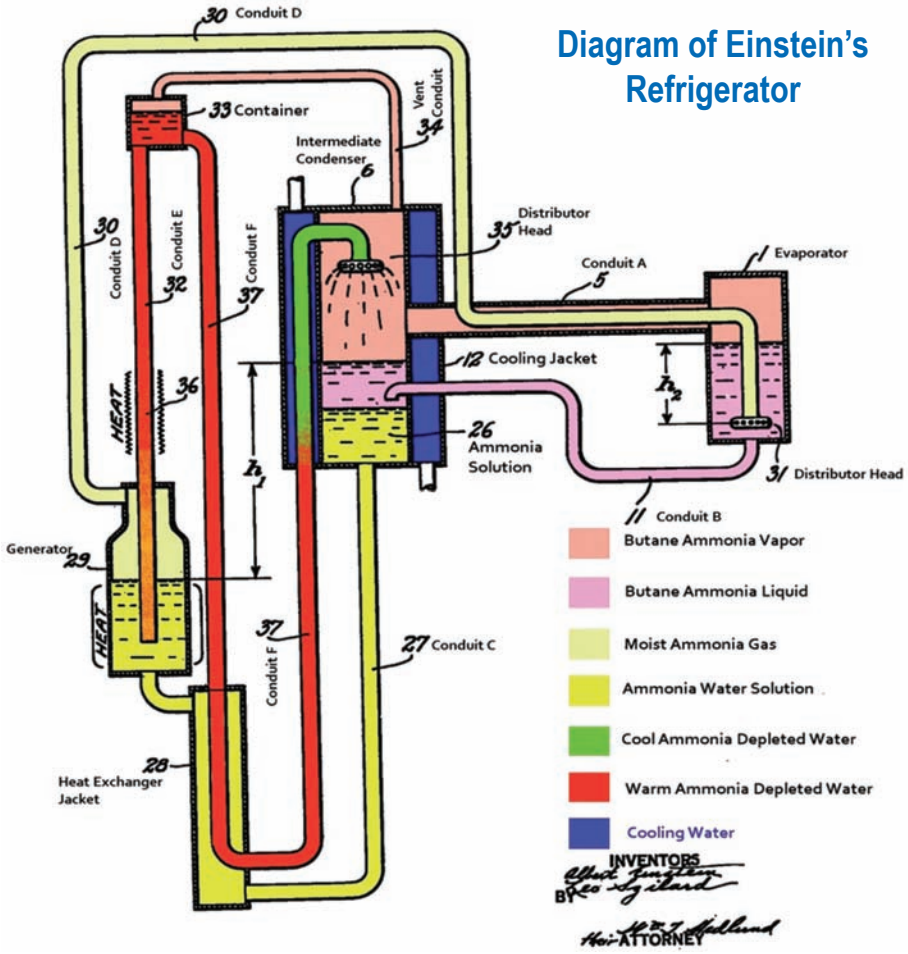


Diagram of Einstein's Refrigerator



Science Behind Einstein's Refrigerator

It is a single pressure absorption type refrigerator. Here butane is used as refrigerant, ammonia as pressure controlling agent and water as absorbing fluid. In any absorbing refrigerator, two fluids are required, one for refrigerant and another as absorbent. For example, in the ammonia-water cycle, ammonia is the refrigerant and water is the absorbent.

In Einstein's refrigerator, Einstein and Leo Szilard used two flow loops (ammonia flow loop and water flow loop) and three fluids (ammonia, water and butane) and successfully avoided the moving parts by applying their knowledge of physics. With the standard working fluids, a water-flow loop serves as an ammonia pump, and the ammonia-flow loop serves as a butane pump. Ammonia and water are suitable choices because ammonia is highly soluble in water and its solubility declines steeply with increasing temperature. Butane is a suitable choice for the refrigerant because it has a suitably low boiling point and is virtually insoluble in water.

In conventional refrigerators, two operating pressures work. A refrigerant evaporates at a temperature-dependent pressure. Evaporation absorbs heat from whatever is being cooled, and the vapor flows to a compressor. In Einstein's refrigerator, in the evaporator they used a mixture of ammonia and butane. Let the pressure of the system is Ps, and partial pressure of ammonia be Pa and butane be Pb. Then P=Pa+Pb. Here butane changes its phase (from liquid to gas) due to its own partial pressure Pb and creates the cooling effect and ammonia act ass pressure equalizer. The expansion of butane (liquid state to a gaseous state) acts as a pump and helps to flow the moist ammonia to another loop.

In the condenser the ammonia gets dissolved in water, as a result the partial pressure of butane increases, which helps to change its phase (gaseous to liquid). As it is insoluble in water, it floats over it and ammonia will act as a pump to move it to the other loop.

On the other hand, the mixture of ammonia water will move into the ammonia generator chamber and will be heated by the external heat (the input of this system). This ammonia will mix again to form a butane ammonia mixture. In this way the cycle will go on.

What happened to the Einstein-Szilard Refrigerator?

Einstein and Szilard had to overcome many challenges. Some of the designs were too noisy, some not as efficient as they would have liked. Still, they received 45 patents in six countries for refrigeration technology.

Yet none of their inventions ever reached the customers. The project was dropped for a number of reasons. The worldwide depression certainly didn't help things. But the 1930 invention of Freon was the real killer of the Einstein-Szilard refrigerator. Freon was a non-toxic refrigerant, so the danger of leaking was eliminated. There was no longer a need to redesign the refrigerator.

Though the commercial production of this refrigerator stopped, the pump was later incorporated into the cooling systems of nuclear breeder reactors.

Is the Einstein-Szilard refrigerator relevant today only from the historical point of view? Times have changed. A refrigerator that lasts 100 years and uses less energy looks highly attractive today as we are trying to discover ways to live with more efficient, less disposable things. Besides, the coolant Freon is now recognized as a serious environmental hazard. So, are there any chances that Einstein's refrigerator may come back in some modified way?

It just might be. Actually, The idea that had been gathering dust for 70 years was resurrected recently when Andy Delano, a Georgia Tech graduate, started research into Albert Einstein's work and produced some chilling results. In 2008, "Time" honored scientists at Oxford University – led by engineer Dr. Malcolm McCulloch – with a "best invention" award for new research based on the Einstein-Szilárd designs.

Although it's more than 80 years old, the Einstein refrigerator could be one example of an idea that is relevant today.

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SHORT FEATURE

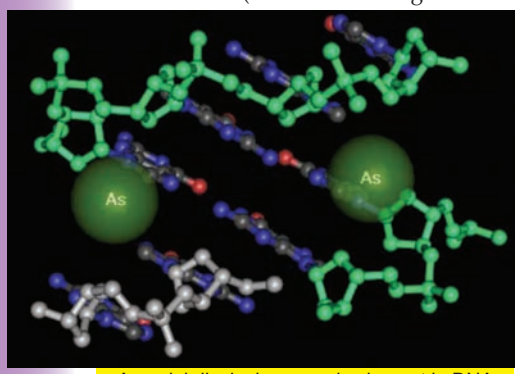
Could Lethal Arsenic be a Quintessential Part of DNA?

DEBASISH KAR

ARSENIC isn't something you would like to eat. It is considered to be one of the deadliest poisons on Earth. It has a bad reputation as it contaminates the drinking water of millions of people. It almost acts as antagonistic to life as a chemical.

However, Felisa Wolfe-Simon surprises the entire world with a provocative finding: strange bacteria in the Mono Lake, California that thrived on something completely unexpected – arsenic. Measurements on arsenic DNA analogs made by researchers revealed that the arsenic analogs differed in stability from their phosphate versions by a mind-boggling factor of 1017. Reasonably it suggested that a different kind of life could possibly exist on some other planet.

The story began when scientists led by Felisa Wolfe-Simon of NASA's Astrobiology Institute published a paper that articulated that the bacteria, found at Mono Lake (known for its high arsenic levels) in eastern California, could grow by replacing arsenic for phosphorus.



A model displaying arsenic element in DNA

Their paper raised eyebrows because phosphorus was believed to be essential for life, while arsenic being chemically similar is a poison. If the bacteria can break rules like this, some argued, who knows what kinds of life may be possible beyond Earth?

Of the numerous elements in universe, life is mostly made up of just six: carbon, hydrogen, oxygen, nitrogen, sulphur and phosphorus. This elite clique is entailed to be omnipresent and irreplaceable. But the Mono Lake bacteria may have broken their dependence on phosphorus by substituting it for arsenic.

If this was true, they would be the only known living organism to do so. The discovery is amazing and it would imply that "Mono Lake was home to a form of life biologically distinct from all other known life on Earth" and "strongly suggests that life got started on our planet not once, but at least twice".

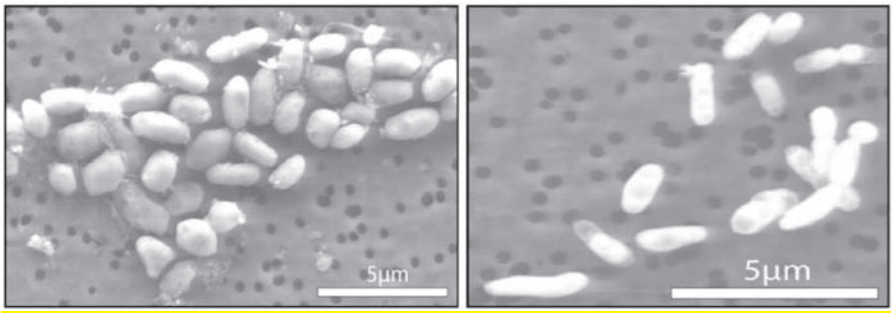
GFAJ-1: An Arsenic Lover

Mono Lake lies in a sealed basin close to California's Yosemite National Park. With no outlet connecting it to other bodies of water, any chemicals streamlined into the lake tend to stay there. As a result, the lake has fortified some of the highest concentrations of arsenic on the planet. To survive there, bacteria have to contend with the poison.

The bacteria, called GFAJ-1, a member of the genus Halomonadaceae, live in Mono Lake, amidst concentrations of arsenic that would kill most other life forms. During a 2010 NASA news conference, Felisa Wolfe-Simon announced GFAJ-1 was incorporating arsenate (a form of arsenic) into its DNA in place of phosphate. Earlier, Ronald Oremland discovered bacteria in Mono Lake that can fuel themselves on arsenic.

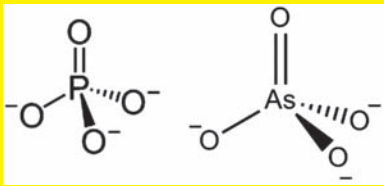
Wolfe-Simon is further establishing that the bacteria are incorporating arsenic into their most significant molecules of life. She had collected sediment from Mono Lake and cultured it on Petri dishes, provided a soup of vitamins and other nutrients, but without any trace of phosphorus. She took samples from these dishes and cultured them to fresh ones, gradually diluting them to get rid of any phosphorus that might have packed onboard. She kept on adding more and more arsenic throughout the experiment.

Astonishingly, bacteria still grew in the dishes. She isolated one of these arsenic-lovers, a strain called GFAJ-1. Using a sensitive technique called ICP-MS she demonstrated that these bacteria did indeed contain large amounts of ubiquitous arsenic. Wolfe-Simon exposed bacteria with a mildly radioactive arsenic to track its pathway and surprisingly she detected arsenic everywhere. Arsenic could able to successfully replace phosphorous to become an essential element of bacteria's proteins and fats. Most importantly, it was integrated into



Bacteria grown on arsenic (left) and phosphorus (right)

This elite clique is entailed to be omnipresent and irreplaceable. But the Mono Lake bacteria may have broken their dependence on phosphorus by substituting it for arsenic. With no outlet connecting it to other bodies of water, any chemicals streamlined into the lake tend to stay there. As a result, the lake has fortified some of the highest concentrations of arsenic on the planet.



Structural similarity between phosphorus and arsenic

ATP and even in their DNA. These results were confirmed from a number of other techniques.

Today, all other life employs phosphorus to make the backbone of the universal double helix, but GFAJ-1's DNA had a rachis of arsenic. Wolfe-Simon noticed that bacteria became 50% larger if they were allowed to grow on arsenic compared to phosphorus, and they evolved a large internal compartment called vacuoles.

These might be the key to their survival. Wolfe-Simon thinks that the vacuoles could act as a safe garden for unstable arsenic-based molecules they might contain, chemicals that steady the molecules, and they might exclude water that would accelerate their breakdown. It's an awesome result, yet there is a question to be asked. Wolfe-Simon still found an iota of phosphorus in the bacteria by the end of her experiment. The level of phosphorus was so low that the bacteria had no option to grow but it's still not clear how important this phosphorus element is. Could the bacteria have literally been able to come through if there was no phosphorus at all?

Can Arsenic Bind to DNA?

In 1987, the eminent physical organic chemist Frank Westheimer published an article entitled "Why Nature chose Phosphates". He addressed all aspects of phosphorus for being mostly chosen. However, in this publication, he considers other potential elements that might imaginably accomplish a similar function to phosphate, its esters, and anhydrides.

One of these is arsenate, which is indeed an attractive alternative due to the similarity of its basic structure as a tribasic acid capable of forming esters and anhydrides and almost identical pKa values. The original trademark of phosphate chemistry is the enormous hydrolytic stability of phosphodiesters which is an important cornerstone for DNA stability.

Chemists therefore wondered when Wolfe-Simon claimed what was considered to be evidence that a bacterium from the arsenic-rich Mono Lake in California, Halomonas strain GFAJ-1, could grow in the absence of phosphate and instead use arsenate.

How Stable is the Arsenic-substituted DNA?

To understand the stability of arsenic substituted DNA, researchers considered five types of phosphate binding protein (PBP) which bind phosphate in a biochemical pathway that contributes the cells from four species of bacteria. However two of the bacterial species were resistant to arsenate and two were sensitive to it.

To decipher how effectively these proteins discriminate between phosphate and arsenate, the researchers placed them in solution with a defined amount of phosphate and different concentrations of arsenate for 24 hours, and then assured which of the molecules the proteins would bind to. In the solutions containing 500-fold more arsenate than phosphate, all five proteins were still able to preferentially bind phosphate. It was only one protein, from the Mono Lake bacterium, that could do so at arsenate excesses of up to 4,500-fold over phosphate. It shows that this bacterium has evolved to extract phosphate under almost all circumstances.

The exceedingly high preference for phosphorus found in the key proteins in that species represents "the last nail in the coffin" of the hypothesis that GFAJ-1 uses arsenic in its DNA.

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An Autobiography of Bacillus thuringiensis

PRIYANKA HALDAR

HI all. I am in an ecstatic mood today. I got another feather in my cap. Yes, I am Bacillus thuringiensis's strain kurstaki. After corn, cotton and maize now I also enter, Oh, I mean my cry1Ac protein successfully enters Lepidopterons to give insect-resistant tomatoes. Yippee! My ubiquity in soil is I believe what makes me stay grounded inspite of all the scientific attention I receive! Ha ha ha. No, but seriously, I am quite a modest bacterium.

But, I somehow bear a grudge against these Lepidopterons. And thanks to all you researchers who optimally used my abhorrence against them. I paralyze their guts after forming pores by my delta endotoxins. But nonetheless, my proteins are not susceptible to live stocks and humans.

My insecticidal component machinery is not limited to endotoxins. I also use zwittermicins, phospholipases, chitinases, vegetative insecticidal proteins, Cyt proteins and spores to combine together with the endotoxins and paralyse the insects.

I remember the other day talking to israelensis (Bacillus thuringiensis subspecies israelensis) when he was acknowledged for mosquito management by Colorado university. Born in the Negev desert of Israel, my brother is extremely toxic to larvae of many mosquito species. This broad spectrum action on mosquitoes and other flies has gained him popularity. One of his most important contributions was in the Onchocerciasis Control Program. Onchocerciasis aka River Blindness, is a human eye disease, caused by a parasitic worm carried by Black fly. Israelensis used his complex parasporal body against these Dipterans. And now, aizawai, my brother (Bacillus thuringiensis subspecies aizawai) is also been recently exploited for mosquitocidal activity especially against dengue, the dreaded fever. Keep up the good work bro. His Cry1C protein is highly toxic to the larvae of Aedes, Culex and other mosquitoes.

I feel so proud in helping the human community who have come up with some merits utilizing us – the bacilli, who were once known only to cause Anthrax or Tuberculosis or even tooth decay. Finally, having a gram positive attitude towards life is what always helps. Ha Ha Ha....

In this list of accomplishments, I shall never fail to mention my gratitude towards Indian scientists, who made me famous all over the world though their scientific studies and country wide application of my utilities, specifically in the agricultural sector. The widespread use of Bt Cotton in India made it the number one global exporter of cotton. The poor farmers were happy, the yield increased, they witnessed resistance against American bollworm, pink bollworm, spotted bollworm, also the hectarage of cotton cultivable land increased owing to high yields and demand.

Pest management has always remained our prime focus from the day we were born. Be it cotton, egg plant or maize, Bt crops are a boon to a country's economy. I along with all my genetic divergence in the form of various strains will continue our fight against the insects and save your crops and give greater net returns in terms of yield. Right from Thuricide concentrates or mosquito dunks to larvicide dusts, we can be easily found in all the products aiming to eliminate pests and insects. One of my isolates HD1 can be found as a commercial formulation named Dipel.

On one of our get-togethers, my brother morrisoni spoke about his travel from one lab to another, one petri plate to another. But in one such study, when researchers cultured him in glucose and salt-containing media, they forgot to adjust the pH of the media! Oh! I can understand how much painful was it for morrisoni to solubilise his parasporal body in the wrong pH. Ususally, alkaline solutions activate our endotoxins, but every different brother of mine has his own particular pH requirements.

It is on such get-togethers that we spend a gala time with our kith and kin and also discuss our achievements in various research studies. Travelling without a passport, communicating without mobile phones, but still being connected with our family is some thing homo sapiens could never enjoy! Complex eukaryotes …Ha ha ha ha… So, prokaryotic life, Zindabaad !!!!!

Nostalgic, but it is a genuine feeling guys! As if it was just the other day when I was discovered by Dr. Shigetane Ishiwatari. Yes, our spores and crystalline insecticidal proteins have been exploited only since the 1920s but it's been 110 years since our discovery. Our gene is inserted into the plant's DNA where it can secrete Bt-toxins and finally help combat major agricultural challenges. Recombinant DNA technology and other scientific advances have helped us prove our worth. I wish, there be many basic and applied research studies on us and we are able to serve man in sectors other than agriculture too.

Some of my other applications could be in the food industry where my chitinases could be isolated and used for food preservation. Also, in the agricultural sector, I wish to provide insecticidal resistance to frut crops, celery and others. I wish to provide abiotic stress resistance too to crops. My wish list for serving mankind in the area of insect as well as pest control is endless. Our entire genome has been sequenced by scientists; hence I am confident that my wishes will sooner or later be fulfilled by them.

Humans have made me a celebrity from a mere bacterium. I and my brothers (aizawai, israelensis, japonancis, san-diago, morrisoni and many more strains) would certainly remain indebted to the human race for giving us the accolades in lieu of our services to them. Thanks all. Reap as much benefits as you can. We are at your service.

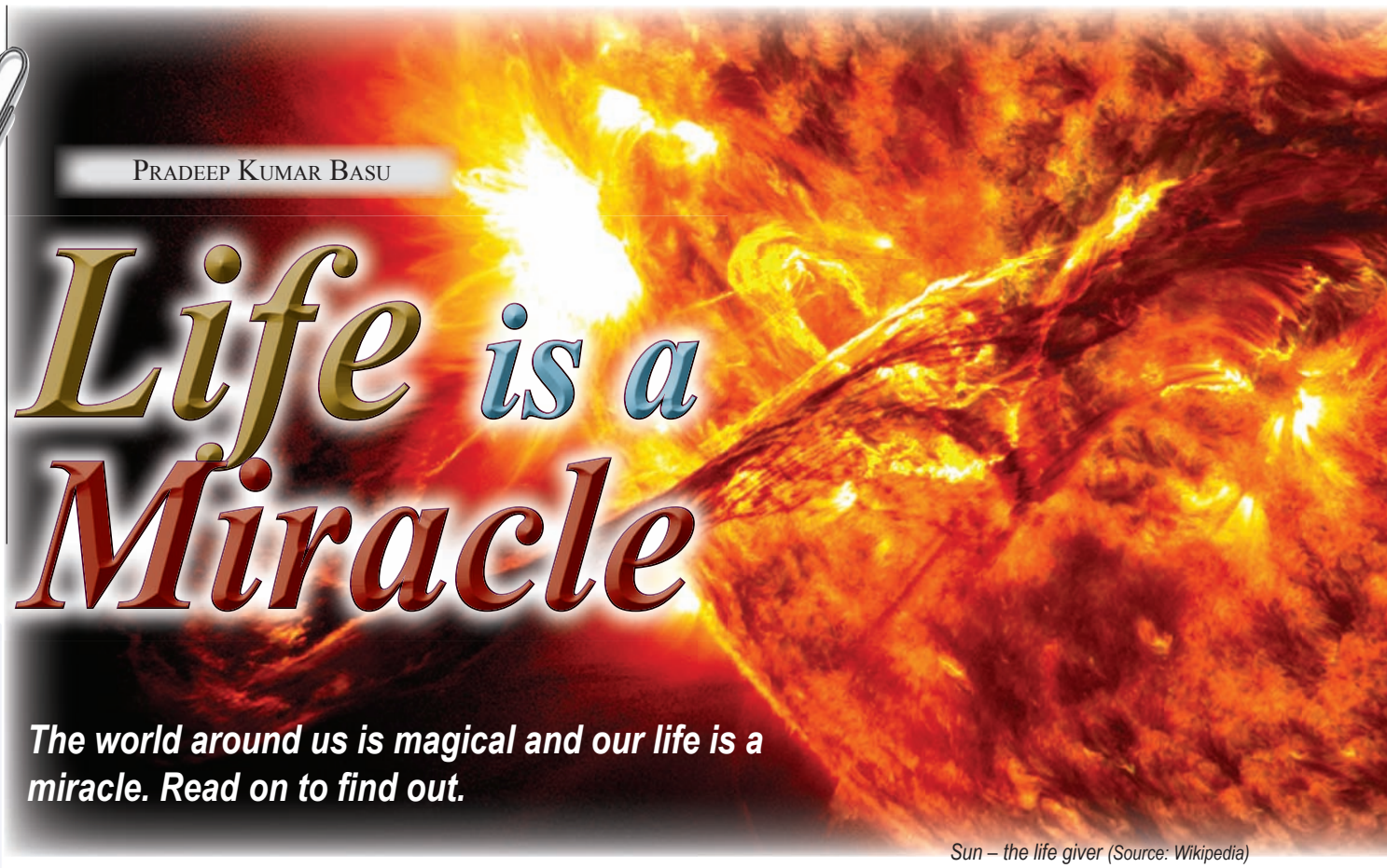
Ms Priyanka Haldar is a Masters in Biotechnology from Bangalore University and has a professional experience of almost six years as a researcher in pharma and drug discovery. Address: Flat No.3, Raj Plaza, Anand Park, Dange Chowk, Thergaon phata, Pune-411033

FEATURE ARTICLE

PRADEEP KUMAR BASU

Life is a Miracle

The world around us is magical and our life is a miracle. Read on to find out.



Sun – the life giver (Source: Wikipedia)

MOST of us go through life unaware of the great mysteries of the universe that surround us, which if we knew, would fill us with wonder and awe. I present here a few.

Even primitive societies realized that the Sun is our life giver. Hence, in all cultures around the world, the Sun is a revered figure. If you look at the Sun with naked eyes, what you see is a flat white or red disc radiating heat and light. But appearances can be deceptive. When the Sun is examined under powerful telescopes, both ground and satellite based, using the various frequencies of the electromagnetic spectrum, they show a huge turmoil going on inside it, as is to be expected inside a star.

The Sun's core temperature is ~16 million degrees (C, F or K, I leave it to you!) though the Sun's surface is at a comfortable (for us!) 5850 K. Inside the core, each second, 700 million tons of protons are being fused together to produce Helium nuclei, releasing energy equivalent to 90 billion megatons of Hydrogen (fusion) bombs/sec. But such is the chaos inside that a photon produced near the core undergoes so many collisions with ions that it may take more than 100,000 years to reach the surface! (The Sun's diameter is roughly 108 times that of the Earth). From there, it reaches us in eight minutes.

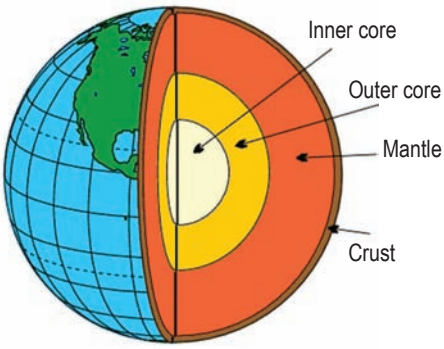
Isn't it wonderful to contemplate that every time you gaze at the Sun, the photons that strike the retina of your eyes, started their journey from the sun's interior at a time when your distant fore fathers were living in caves, leading a hunter-gatherer existence?

Now let's get back to Earth. The Earth below our feet looks solid and supportive. It supports huge mountains, sprawling metropolises, big dams and other structures weighing millions of tons. Its average temperature is 288 K. The only time it gives us trouble is when it quakes. But looks can be deceptive.

We are the residents of the Earth's solid crust which in depth varies from 6 to 50 km only all over the globe with an average depth of around 20 km. You will realize how precarious it is when you compare it with the Earth's radius of 6378 km. If you imagine the Earth to be a globe of 1 metre radius, you will realize that most of us spend our lives within a few millimetres!

The continents are actually islands of rock called plates, floating on a semi-solid slow-moving high-temperature layer called the upper mantle. You get a taste of its contents when volcanoes erupt spewing molten lava all around. This layer further rests on a faster moving lower mantle at a still higher temperature. Then comes the Earth's core which consists mainly of a sphere of iron at temperatures above 4000 K and pressures of more than 1.3 million atmospheres. Under these conditions, iron is in a liquid state. At the very centre of the Earth, where pressure and temperature rise even higher, the liquid iron solidifies. Latest data shows the core to be at 6000 K. The pressure there is 3.3 atmospheres.

Some of you may wonder how we get to know the Earth's temperature at the core. The answer is, by simulation experiments using principles of physics. A speck-sized piece of iron is thermally



The Earth – our home

Volcano – Getting a taste of the Earth's contents

The Earth below our feet looks solid and supportive. It supports huge mountains, sprawling metropolises, big dams and other structures weighing millions of tons. Its average temperature is 288 K. The only time it gives us trouble is when it quakes. But looks can be deceptive.

isolated and placed between two tips of diamond. Pressing the diamond tips together allows you to get the pressure you want to generate. Simultaneously, a laser beam heats the iron to the required temperature. A thin beam of X-ray radiation comes out of the sample. Analysing the diffraction pattern of the X-ray beam gives information about the state the iron is in: solid or liquid. The experiment in practice is very difficult to carry out with good accuracy.

The temperature difference between the mantle and the core is the main driver of large-scale thermal movements of the liquid iron, which together with the Earth's rotation, acts like a dynamo generating the Earth's magnetic field. This magnetic field protects us from high energy cosmic radiations plus the occasional coronal mass ejections (CME) from the surface of the Sun. These ejections take 2-3 days to reach us. The major part is stopped by the magnetic shield but some part goes along the magnetic lines of force and interacts with the ions in the top layers of the Earth's atmosphere. Thus, we get the wonderful display of colours called aurora borealis and aurora australis in the North and South Pole skies respectively. If the CME is very strong, sometimes communication networks are affected and power grids trip.

But how does the interior of the Earth get heated up to such high temperatures. Together with the residual heat from its fiery birth, there is heat produced by the decay of radioactive uranium, thorium and potassium inside the Earth. Studies of antineutrinos coming from inside the Earth show that 49% is due to radioactivity; rest is the residual heat of creation. You can have an idea of its magnitude from the fact that 44 trillion watts of heat rises from the depths and is dissipated by the surface of the Earth. But the Sun bathes us with 1 kW/m^2, an energy we are using these days to generate electricity as well as for directly heating water!

The important fact to note is that if we did not have the magnetic shield, we would not exist; rather no life on land would exist. In the beginning years of our 4.54 billion years of history, the magnetic field was weak, so life arose first in the sea, where the water acted as a shield for the radiations. Only when the magnetic field became strong enough did life migrate to land. We owe our lives to it. If our forefathers knew of this fact, surely we would have had a God for Magnetism.

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Now, let's come to the human civilization. All primitive societies worshipped plants and trees primarily because they supplied food, wood for houses and fire for cooking as well as for scaring away wild animals in the night. Also, many plants had medicinal values.

But there is a much deeper reason. This we came to know only after science made considerable progress. Just as we would not have been here without the magnetic shield around us, we would not be here if plants were not there!

When the Earth was formed 4.54 billion years ago (bya), it was a burning globe. Slowly over time it cooled down. Land and oceans came into existence. Based on secondary clues, scientists have worked out a rough scenario of the changes in the atmosphere with time. The original atmosphere was made of Hydrogen and Helium. Around 2.7-2.8 bya, around 1% Oxygen formed, probably from water molecules ripped apart by UV light. Around 2.2-2.4 bya it was 5%.

Volcanic out-gassing gave an atmosphere of Carbon dioxide, Sulphur dioxide, Carbon monoxide, Chlorine, Nitrogen, Hydrogen, and water vapour – a poisonous cocktail. Slowly, starting from unicellular organisms life arose in the sea. When the magnetic shield became strong, those primitive lives started migrating to the land. But the stage was not yet ready for us. By 2.45 bya, the oxygen level was between 1-10% mainly created by the cyanobacteria. In between, the oxygen level rose as high as 33%! Only around 400 million years ago, it reached the present level and oxygen-breathing life started taking the upper hand. So, our forefathers reverence for plant life was not misplaced. We owe our very existence to them!

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From the day of your conception, you are traveling. Earth, clasping all her children, black or white or yellow, rich or poor, is going round the Sun at a speed of 30

Aurora borealis – wonderful display of colours
(Source: Wikipedia)

We would not have been here if plants were not there

When you are jettisoned to this world, you are typically 51 cm in length, 3.4 kg in weight. In nine months, you have grown 2500-5000 times in length and ~107 times in weight, all from the master blueprint engraved in a single cell!

km/sec. The Sun with its Solar System is a member of the Milky Way Galaxy. Together with its planetary family, it is going round the centre of the Milky Way at 220 km/sec (that is Delhi to Agra in a blink of the eye!).

The Milky Way is also not standing still. It is rushing at a speed of 532 km/sec from the centre of the known Universe. If we assume that we have a life expectancy of around 70 years, for an average Indian, then since conception to death, you would have traveled more than 1,000,000,000,000 km from the point where the Earth was, when you were born! No wonder poets wax eloquent about life's journey. If they only knew how long it really is!

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And now, to our bodies. A tiny weenie egg waits in your mother's fallopian tubes. Its nucleus has 23 chromosomes – half the genetic code required for you. The egg has a diameter of 100-200 micron and weighs around 60-100 micrograms. Around 400 million sperms from your father take part in the race to enter the egg. The sperm is even smaller. It has a head around 5 micron and tail of 20 microns. Its head has a cap called acrosome that has special enzymes which will help the sperm to penetrate the egg.

But nature believes in survival of the fittest. So, as the sperms race through the vagina and cervix they encounter an acidic flow. The sperms valiantly swim through this flow thrashing their tails, but only a few thousands make it to the other side. Roughly 1 in 106. But the ordeal is not yet over. They then have to overcome the defences around the egg.

Ultimately one brave and sturdy sperm breaks through into the egg. It fuses with the nuclei completing the 46 chromosomes which is the total blueprint for you. It is as if the entire population of a country, having a population greater than that of the United States (315 million), took part in a race, and only one person reached the finishing line! (Of course, in rare cases more than one does make it. Modern day record of surviving children is octuplets.

Then there are various complicated steps through which the egg goes until we are born. For instance, immediately after fertilization, the egg starts dividing at a furious pace. Initially, all the cells are the same – the stem cells. Then at a signal, the cells spread out and start developing into different types of cells: brain cells (neurons), skin cells, bone cells and so on. There are in all 220 types of cells in our body.

Each cell somehow knows what organ it has to become. You can realize the furious pace at which they work from the fact that your heart starts beating in 4 weeks! Your lungs are also there but they don't start functioning till you are born. Your mother's body takes care of you till you are born. It provides you the oxygen and other nutrients for growth. It takes away the waste products. It protects you from various germs.

At last, you are jettisoned to this world. You are typically 51 cm in length, 3.4 kg in weight. In nine months, you have grown 2500-5000 times in length and ~107 times in weight, all from the master blueprint engraved in a single cell!

The population of the Earth is a huge number: 7 billion ($7x10^9$). You are aware of the poverty, illiteracy, disease, religious bigotry, genocide, and war that plague most of them. But your body has 10 trillion (10^{13}) cells working in smooth harmony, each carrying out its assigned task routinely, meticulously. Add to this another 100 trillion (10^{14}) friendly bacterial cells, who occupy different nooks and corners of the body. You feel humble when you discover that you, *Homo sapiens*, Lord of the Earth, are 9/10th bacteria! And this complicated system is efficiently run 24x7 by the 1011 neurons (brain cells) with you being none the wiser!

Won't you now agree that the world around us is almost magical and our life is a miracle?

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Heating in Cold Climes

Designing homes to draw in more sunlight and keep living spaces warm is the goal of Passive Solar Architecture.

HILAL AHMAD BHAT

THE household sector is perhaps the single largest consumer of energy in the nation's economy. In cold climatic regions, substantial energy is consumed for space heating through both commercial and non-commercial sources of energy e.g. fuelwood, LPG, kerosene, electricity, crop residues, etc.

In contrast to active methods of solar heating of dwellings, solar passive methods do not require the use of mechanical equipments like pumps or a blower. Passive solar houses are located and oriented to take advantage of climate and surroundings for keeping the inside comfortably warm.

Passive solar heating uses building components to collect, store and distribute the sun's heat to reduce energy demand for space heating. The thermal energy flows through the living space by natural means (conduction, convection and radiation) and thermal storage is in the structure itself. Also, during the day passive solar heating reduces the use of artificial lighting.

The concept of Passive Solar Architecture is not new. Various solutions have been found for protection against climatically harsh conditions through locally available materials. For instance, in hot and humid regions of Asia, Australia, Polynesia and Amazon, the roof has been more important than walls for modifying the indoor environment. On the other hand, in the mountainous cold regions e.g. North West USA, Scandinavia and Himalayas, well-insulated timber houses are found.

In case of vernacular architecture, the roof has played a determining role in the general form and appearance. For example, flat roofs appeared in hot regions, vaulted roofs in hot and dry regions and inclined roofs in temperate-dry climates. In wet-temperate and cooler places higher pitched roofs were used. In proto-historic period, community-based collective house forms evolved.

In vernacular residential architecture, bioclimatic aspects such as orientation, house form, and open spaces were given due consideration. For instance, the ancient Greeks gave their homes a southern orientation and used thermal mass for heating purposes. Thick earthen walls stored the heat and prevented air infiltration. The Romans later improved their technique to incorporate clear window coverings, greenhouses and radiant floor heating. Natural lighting through clerestories and skylights has been used in many historical buildings such as the temple of Amman at Karnak and the Pantheon at Rome.

Let's take a look at some Passive Solar systems used for heating of buildings.

Direct Heating: For direct heating, the sunlight is admitted through a window or a glass wall facing south to admit maximum sunlight in winter to heat up

The buildings in cold climate should be clustered together to minimize exposure to cold winds.

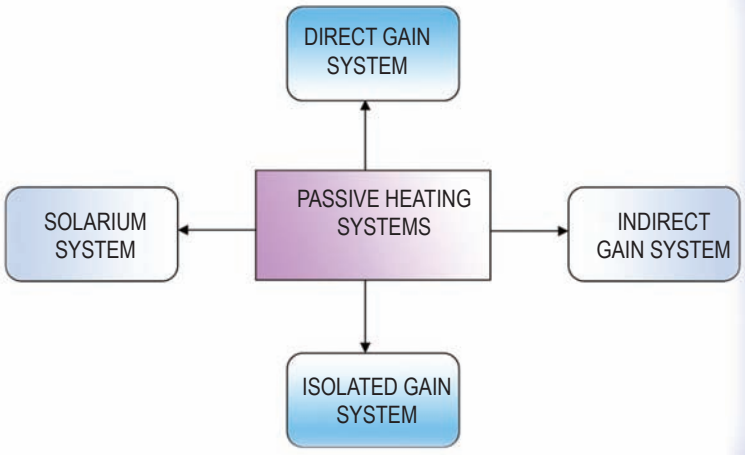


Figure 1: Solar Passive System

Flat roofs appeared in hot regions, vaulted roofs in hot and dry regions and inclined roofs in dry climates.

the walls, floors, objects and air inside the living space. In this approach, the space becomes a live-in solar collector, heat storage and distribution system. This system collects and uses every bit of energy that passes through the glazing – direct and diffuse.

Because of its simplicity and effectiveness, direct gain features are used extensively for heating purposes in cold climates. Besides being a simple and low cost technique, the main disadvantage of the direct gain approach is large temperature swings due to undesirable winter losses and summer overheating. The approach is therefore preferably used for office buildings having daytime occupancy.

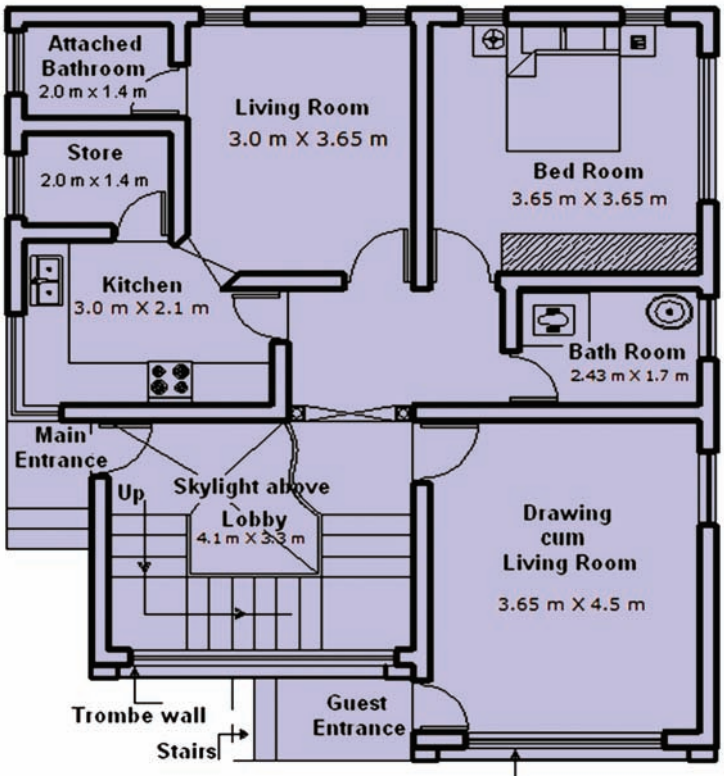
Indirect Heating: In indirect heating, the sunlight is intercepted directly behind the glazing by the thermal storage wall. The energy absorbed by the thermal storage wall is converted into heat energy and then transferred to the living space. The indirect heating approach is preferred for residential heating purposes. Its advantage over direct heating approach is more uniform room air temperature.

Different materials are used as thermal mass for storing thermal energy e.g. a Trombe wall, a water wall, and a Transwall. After storage of thermal energy, it is released slowly during the off sunshine hours with minimum fluctuation of heat energy. The amount of heat released for thermal comfort can be optimized by proper design of the storage.

Trombe Wall System: Trombe wall system is an indirect heating system in which there are openings at the top and bottom of the wall to allow air to heat by natural convection. The wall facing the southern side is painted black to store the heat along with the glazing. CSIR-CBRI (Central Building Research Institute), Roorkee has designed the Navodaya Vidyalaya at Kargil in Jammu and Kashmir province using the Trombe Wall System.

Solarium System: This is a combination of direct heating and indirect heating system. Solar greenhouses or Solarium systems are used to maintain comfortable

Figure 2. Floor Plan of the Proposed Passive Solar House



In wet-temperate and cooler places higher pitched roofs were used. In proto-historic period, community-based collective house forms evolved.

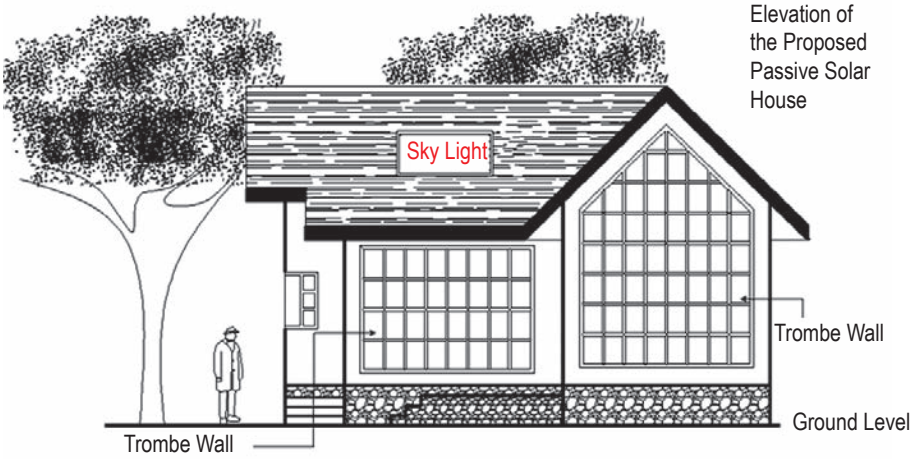
indoor temperature and to grow vegetation. In this system, the glass enclosure called sunspace is provided on the southern side of the building. As the sun shines, the sunspace temperature rises up and the main building is warmed up slowly by convection.

Solar Passive Design in Cold Climates

Passive building is an environmental design approach that minimizes the dependence on commercial and non-commercial energy sources. In cold climates, trapping and using sun's heat whenever it is available is of prime importance in the design of residential buildings. Providing insulation of building elements and control of air infiltration is essential, so that the internal heat is not lost back to the ambient.

The design of solar passive building is climate-specific. Various stages of design involved in the fabrication of passive solar residential buildings are site location, orientation and building form, building envelope design, daylighting, etc. In designing passive solar buildings in cold climatic regions like Kashmir valley, the following design guidelines need to be followed.

Figure. 3. South Elevation of the Proposed Passive Solar House



The roof is made of galvanized iron sheets having a steep slope for quick drainage of snow and rain water. The construction materials employed are locally available.

Site location: To maximize the solar heat gain, buildings should face south for better access to solar radiation. The buildings should receive sunlight between 9.00 a.m. and 3.00 p.m. (sun-time) during the heating season. The south face of the building can have maximum glazing area but the north side should have minimum. To prevent exposure to cold winds, the building should be located on the leeward side.

On the south side, deciduous (leave shedding) trees should be planted so that heat gain in summer can be reduced and in winter sun rays are not blocked. On the north side coniferous trees should be planted so that cool north winds do not take heat away from north walls and windows.

The buildings in cold climate should be clustered together to minimize exposure to cold winds. Open spaces between the buildings should be such that they allow maximum south sun and street width should be large to allow direct sunlight to fall on the south face. The street width should be east-west to allow maximum sunlight to enter the building. To ensure good solar access the street should be wide enough so that the buildings on one side do not shade those on the other side.

Orientation and building form: In the cold climates, the buildings should be compact with small surface area/volume ratios. This is because the lower the surface area, the lower is the heat loss from the building. Windows should preferably face south to encourage direct heat gain and the north side should be well insulated. Living spaces should be kept on the south side and utility areas with minimum occupancy of human beings such as stores can be kept on the north side. The heat generated by appliances in rooms such as kitchens may be recycled to heat other parts of the building.

Building Envelope design: Proper design of the building envelope is a significant part of the energy-efficient house design. The buildings should have steeply sloping galvanized iron sheet roofing with a timber or RCC false ceiling. The advantage of south-facing slope of the roof is that the solar air collector, SPV panel, solar flat plate collector can be easily incorporated on the roof to provide hot air, PV lighting and hot water for space heating, lighting and water heating purposes respectively.

The wall facing south having exposure to solar radiation should have high thermal capacity (such as Trombe wall) so that heat stored during the daytime can be used later. There should be proper insulation of walls on the inner side to minimize the heat losses. It is advisable to keep at least one or two rooms in the building in which mud straw plaster and wood paneling is used for walls so that these rooms can be used as a living space in winter conditions. The external surfaces of walls should be dark in colour having high thermal absorptivity to facilitate heat gain.

Daylighting: To offset the need for artificial lighting during daytime especially in winters, an excess of daylighting is advantageous in cold climatic regions. Since the summers are pleasant, windows must have minimum shading. The usage of clerestories and skylights can be very useful in admitting direct sunlight into the building.

Passive solar residential buildings have been built in large numbers worldwide and the experience has narrowed down the choice to basically two methods i.e. Trombe wall with convection and a Solarium/greenhouse attached to the building. The floor plan of a proposed energy-efficient building in which the major portion of space heating requirements are met through passive solar design is shown in Figure 2. The floor area of the building is ~ 100 m^2. The house is meant for the middle and lower income families.

The south elevation of the proposed dwelling is shown in Figure 3. The design uses south-facing Trombe wall to heat up the interior. The living spaces are kept on the south side and the less used spaces e.g. store are kept on the north side. Since during winter, people prefer to live in a single room to reduce the space heating load, the wall, ceiling and the floor of the living room can be provided with 1.27 cm thick wood paneling to minimize heat losses during off sunshine hours.

Windows of the dwelling are provided with double glazing in contrast with conventional dwellings having single glazed windows with thin 1 mm glass panes. The roof is made of galvanized iron sheets having a steep slope for quick drainage of snow and rain water. The construction materials employed in the design are locally available. The design uses a skylight to encourage direct gain and daylight harvesting in the building.

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FEATURE ARTICLE

Urban Cities — Islands of Heat

MOHD. SAJID IDRISI AND RICHA SHARMA

Urban Heat Islands plaguing our big cities impact our environment and the health of citizens adversely. There is a need to acknowledge the phenomenon and work out mitigation measures.

IT is common knowledge that urban areas are warmer as compared to their adjoining sub-urban or rural lands. This is a phenomenon known as Urban Heat Island (UHI), which is a result of increasing population in the cities that engulf more land for dwelling, resulting in metamorphosis of natural land to artificial urban land cover.

The effect was first investigated and described by Luke Howard, a weather enthusiast from London, in the 1810s although he did not name the phenomenon. This phenomenon is of prime concern today due to increasing climate change linked alterations of ecosystems and communities. Elevated temperatures impact communities in a variety of ways by increasing energy demand, air conditioning costs, air pollution levels and heat related illness and health issues.

Although a new study by Jacobson and Ten Hoeve (2012) published in the *Journal of Climate* showed that urban heat islands are not major contributors to global warming, reducing their effect is still important for slowing the rise of global temperatures. The Urban Heat Island effect may be seen more during cold climates when cities get a warming effect while reducing heating energy needs. It also may help in melting ice and snow on roads. But these benefits are outweighed by the detrimental effects that occur in summertime.

Growing population and thus increasing urbanization are the prime factors responsible for such heat generation. By analyzing satellite images and field measurements, researchers have found that urbanization results in high surface and air temperatures in urban areas, creating urban heat islands. Urban heat islands can modify the microclimate, increasing the occurrence of heat waves during summer and thus increasing the risk of heat mortality in urban populations.

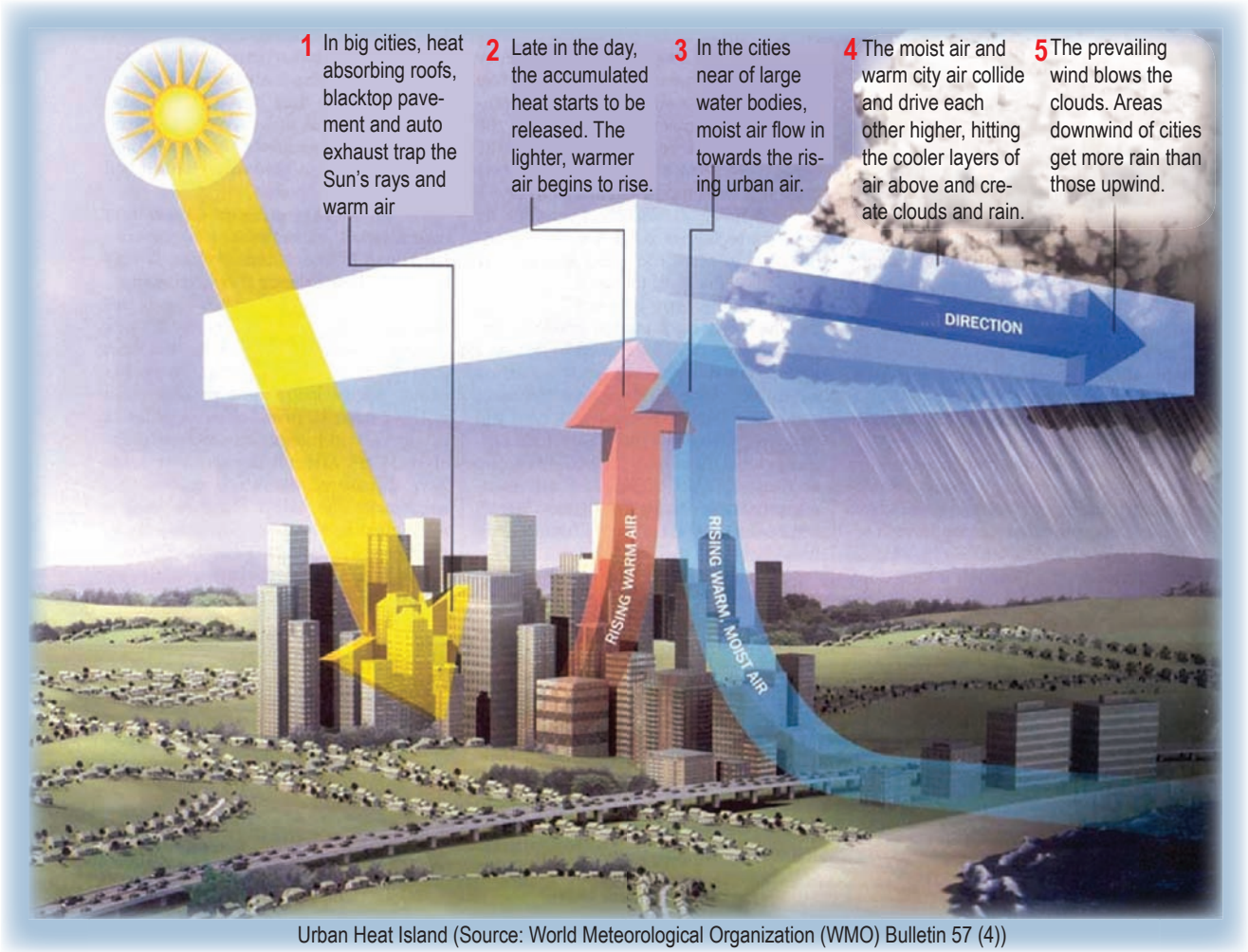
In a study submitted to the Central Government by the Indian Institute of Tropical Meteorology (IITM) it was found that urban heat islands exist in 7 of the 11 weather stations of Delhi (*Down To Earth*, 2014). The temperature of Delhi University (North Delhi), Indira Gandhi Sports Complex (Central Delhi) and Yamuna Sports Complex (East Delhi) between 2010 and 2011 was found to be 3-3.5˚C higher than surrounding areas.

Increasing population and traffic increase the heat load of cities

How Does It Occur?

The principal cause of the urban heat island effect is from the modification of land surfaces, which use materials that effectively store short-wave radiation. This short-wave radiation that was absorbed during the day time is slowly released as long-wave radiation during the night time slowing down the natural cooling process.

Other reasons are attributed to lack of evapo-transpiration due to lack of vegetation in cities and to the thermal properties of materials used in buildings. Building materials are generally good conductors of heat. This conductivity makes the areas around buildings


1 In big cities, heat absorbing roofs, blacktop pavement and auto exhaust trap the Sun's rays and warm air
2 Late in the day, the accumulated heat starts to be released. The lighter, warmer air begins to rise.
3 In the cities near of large water bodies, moist air flow in towards the rising urban air.
4 The moist air and warm city air collide and drive each other higher, hitting the cooler layers of air above and create clouds and rain.
5 The prevailing wind blows the clouds. Areas downwind of cities get more rain than those upwind.
DIRECTION
RISING WARM AIR
RISING WARM, MOIST AIR

Urban Heat Island (Source: World Meteorological Organization (WMO) Bulletin 57 (4))

warmer. Materials such as concrete and asphalt most commonly used for making roofs and pavements in the cities have high surface radiative properties (albedo and emissivity) which results in increase in the temperature in completely concrete areas in contrast to surrounding rural surfaces that are still green.

Impacts of Urban Heat Island

Primarily, UHI impacts health of environment and humans equally. Higher temperatures are known exacerbate the problem of air pollution particularly higher Volatile Organic Compounds (VOC) and Nitrogen Oxide (NOx) emissions which lead to cardiovascular and chronic lower respiratory diseases.

Higher temperatures in areas under influence of UHI tend to decrease the human thermal comfort. UHIs also tend to increase and intensify events of heatwaves, increasing heat-related mortality, especially among the vulnerable sections of society such as children, elderly and marginal sections of society. For instance, the heat wave of 2003 in Europe resulted in more than 14,000 deaths in three weeks in France alone.

Heat can have adverse implications for health of the society as well by instigating irritability, aggressiveness and violence in human behavior. This is particularly true for many tropical countries. Several health implications addressed by the United States Environmental Protection Agency (EPA) includes respiratory difficulties, heat cramps and exhaustion, non-fatal heat strokes, and heat related mortality.

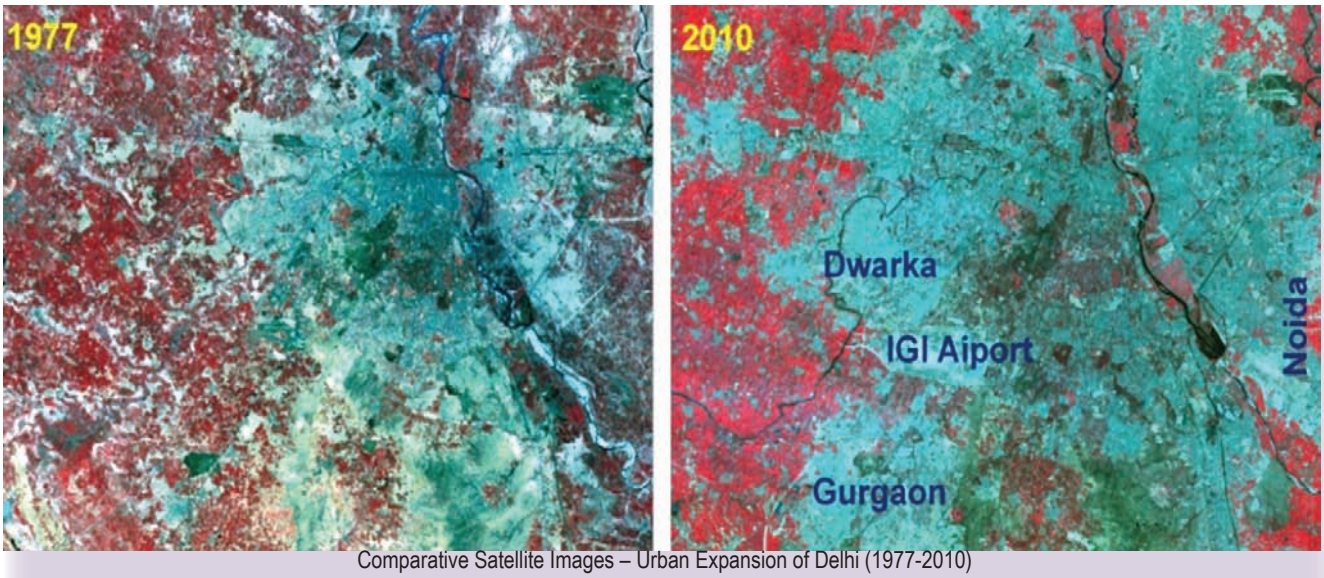
UHI also affects the overall environment of the city area under its influence. The heat from concrete pavements and rooftops impair the water quality through a chain flow from storm water to sewers to nearby water bodies such as streams, ponds or lakes. This can further impact the aquatic biodiversity of such water bodies. One of the most crucial impacts of UHI is impact on micro-climate, affecting the local wind patterns, development of clouds, humidity and fog. UHI in some places has been reported to cause convectional rainfall. Such changes in micro-climate have been found to further impact the phenology of plants in the city.

UHI can also indirectly impact environment and global climate in the long run. It results in increased energy demand for heating and cooling, which in turn results in increased GHG emissions impacting the global climate.

Investigating UHI

Some of the common techniques utilized for investigating Urban Heat Island are:

1. Assessment of Meteorological Data: Weather data from meteorological departments is investigated to know the temperature difference between different sites (mostly a comparison of rural and urban sites). This method was popular in the earlier days, now it is used in combination with other more advanced technologies.



Comparative Satellite Images – Urban Expansion of Delhi (1977-2010)

The urban areas are warmer as compared to their adjoining sub-urban or rural lands. This is a phenomenon known as Urban Heat Island (UHI), which is a result of increasing population in the cities that engulf more land for dwelling,

2. Field Measurements: Actual temperature data is collected through fixed and mobile data stations. Parameters are recorded and processed further to examine the intensity in different areas. This method is also used to establish a relationship between land use/land cover and ambient temperature of the area for planning purpose.

3. Remote Sensing Data: Satellite imageries are procured and land use land cover information is obtained to carry out such studies. Moreover, satellite imageries are used efficiently to get the surface temperature information. ASTER data [Advanced Spaceborne Thermal Emission and Reflection Radiometer] is acquired and processed to get surface temperature which can be utilized as per requirement of the project or any study.

An integration of all these three methods could be highly informative in predicting Urban Heat Island effects.

Some of the instruments used by researchers to study UHI are Automatic Weather Station (AWS), Portable Weather Station, and some handheld sensors such as Pyranometer and Digital Anemometer. Weather stations are used to record parameters such as temperature, wind speed, humidity, atmospheric pressure, precipitation, solar radiation etc. While Pyranometer records sunshine duration and solar duration flux density, Digital Anemometer is used for digital recording of wind speed and direction.

Role of Urban Green Spaces and Water Bodies

Urban Green spaces are important patches which besides providing essential ecological and recreational services to the people, should be seen as ideal candidates for minimizing UHI effect. Heidth and Neif (2008) noted that loss of vegetation in urban areas reduces the amount of cooling by evapotranspiration making them comparatively warmer. Apart from protected and reserved forest patches in cities other green areas such as Biodiversity Parks, community parks and gardens, river floodplains, and institutional greens provide good green cover and soft surfaces to the completely concretised city areas.

Urban water bodies such as lakes, ponds, riverine wetlands, water logged areas and depressions, or marshes though small in size provide essential ecosystem services such as micro-climate regulation, source of drinking water, groundwater recharge, flood control, supporting biodiversity and livelihoods, etc. Unfortunately, being life supporting units in urban ecosystems these water bodies have always been targeted for various development activities.

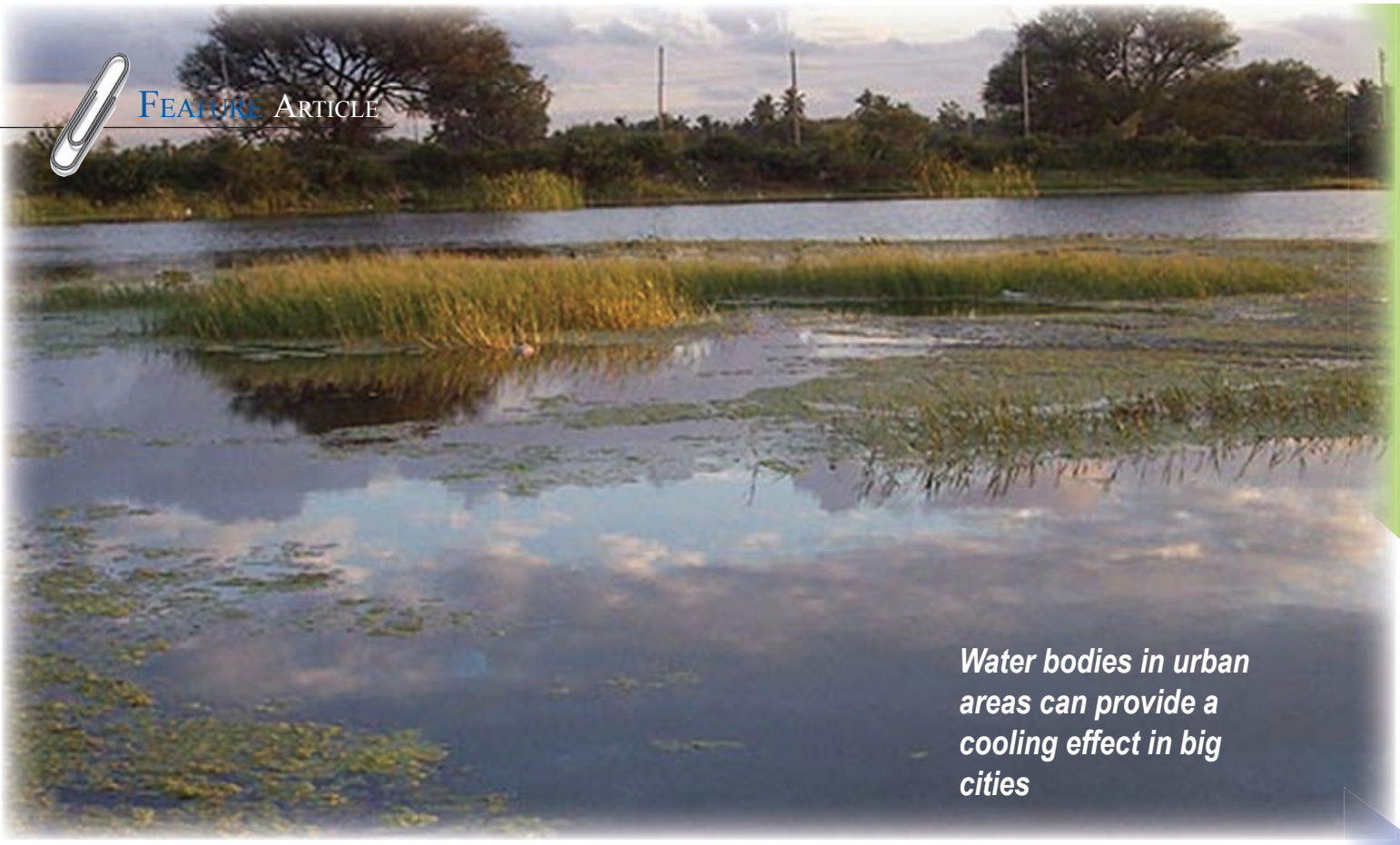
Urban water bodies can play an instrumental role in lowering heat island effect in congested cities. It is generally stated that water surfaces can reduce the temperature of their surroundings by 10 °C. This suggestion is being considered in many cities across the world in proposed mitigation measures.

Olàh (2012) carried out a study in Budapest city, the capital of Hungary, with the use of satellite imageries and concluded that urban water bodies and green surfaces can reduce the effect of urban heat island to a greater extent. In another study, The Heat Island Research Group of the Department of Geography at the Université du Québec à Montréal has studied mitigation measures, planning and regulatory tools for UHI mitigation in Montreal and Toronto and included increase in permeability, surface water catchment and water bodies as an important suggestion.

Take the case of Delhi, one of the densest metropolitan cities. It is home to many water bodies such as Hauz Khas Lake, Sanjay Lake, Bhalaswa Lake, and Najafgarh Jheel which need to be acknowledged for their unequivocal services to Delhiites.

Solutions and Mitigation Strategies Abroad

Development of such heat islands is being noticed across the world. In countries like the United States, heat is the primary weather-related cause of death, and therefore, promotion of strategies for mitigating the UHI are a big concern for government agencies. UHI has been a serious issue in many US cities like Portland, Las Vegas, Albuquerque,



Water bodies in urban areas can provide a cooling effect in big cities

Denver, Louisville, Washington D.C., Kansas, Columbus, Minneapolis, and Seattle to name a few. Even European cities like Stuttgart, Berlin, Padua, London, and Lisbon are facing this challenge and trying to combat it.

UHI mitigation measures include reducing artificial heat emissions, trying to avoid heat build-up by creating wind paths, promoting greening, and improving the material of pavement surfaces. Several strategies and methods have been adopted worldwide to decrease the impact of Urban Heat Islands. Some of them are:

a) Creating Wind Paths: The city of Stuttgart (Germany) has created green belts to direct cool winds from mountains to flow into the city centre. Similar projects are going on in the central parts of the Tokyo Metropolis under its urban renewal project.

b) Greening Ordinance: Nagoya city of Japan has introduced an ordinance where new houses and offices of more than 300 sq m area should have green cover over 10-20% of the lot. Such ordinances may have a greater contribution in curbing the impact of UHI in long term.

c) Green, White and Cool Roofs: Several cities across the world are encouraging Green, White or Cool roofs concept to make the surface more reflective in their efforts to reduce UHI effects. Cool roofs consist of materials that very effectively reflect the sun's energy from the roof surface while Green roofs are an extension of the existing roof that allows plant trees, shrubs, grasses, and other vegetation to grow in a light-weight growing medium. White roofs are carry white color or any other white coating which absorbs lesser energy in comparison to conventional roofs.

Though some of the factors such as prevailing weather patterns, topography, and natural phenomena cannot be influenced by local policy, factors such as land-use patterns, materials used in road and building construction, increase in vegetation cover can make a big difference and can be directly affected by policy makers.

There is a need for concerted scientific efforts and investigations to infer trends across the major cities and their contribution to global warming. Mandatory ordinances and legal instruments such as the one imposed by Nagoya city to increase the green cover may have a significant impact in lowering temperatures of metropolitan cities.

Mitigation solutions such as green, white and cool roofs and change in the building and pavement materials may make a big difference by lowering local temperatures to some extent. Large government and administrative buildings, community houses, schools buildings must be included in UHI mitigation programmes.

The heat from concrete pavements and rooftops impairs the water quality through a chain flow from storm water to sewers to nearby water bodies such as streams, ponds or lakes.

Since urban landscapes and their local environments vary in many aspects, therefore, area specific approaches should be adopted to carry out effective mitigation strategies within the framework of urban planning. Priorities for mitigation measures must be set. Recommendations and UHI mitigation measures must be included in Urban Development Plans.

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Let's Build Happier Cities

If we want to make lives happier for people, let's make our cities better.

ANKIT SHARMA

CLOSE to where I live, every morning hundreds of cars line up at a popular school. From an optimist view, it's a pleasant sight to see. Parents coming to drop off their wards, waving them good byes. All this while a battery of buses arrives one behind the other bringing kids.

But if you were to witness this routine five days a week it does not make for such a rosy picture. At 7:30 in the morning, the fresh crisp air is disturbed by the fuel guzzling cars and buses that try to negotiate their way as close to the school premises as possible, often leading to traffic snarls and incessant honking of vehicles.

Seeing this day in and day out one gets the feeling that there is an immediate requirement for planned infrastructure that is sorely lacking today in most cities of our country. It is ironic that in one of the fastest growing economies of the world, only two cities have planned physical infrastructure development – Chandigarh and Gandhi Nagar.

By 2030, India will witness the largest urban migration in the world with 130 million people migrating to urban areas. By 2021 around 40% of the population would be living in urban areas in India. Going by today's pace of development, in the not so distant 2020 we will face a shortage of 30 million dwellings, 200 million water connections, 350 million sewage connections and 160 GW of power. This is apart from the infrastructure to support a fivefold increase in vehicular traffic.

Today we have just two schemes catering to the vast and urgent need of urban centers – Jawaharlal Nehru National Urban Renewal Mission (JNNURM) and Rajiv Awas Yojna (RAY). While JNNURM focuses on improving urban infrastructure which includes improving conditions in slums, RAY proposes to build houses for the urban poor residing in slums.

While it may seem a perfect solution to address the slum menace in the city, but these housing projects are taken up on the outskirts and are often left midway without providing necessities like water connections or an effective transport link to the city. Coupled with absence of other infrastructure like schools and electricity, there is little incentive left for the poor to live in the houses built by the government.

There have been media reports of rampant corruption in such schemes because of the huge sums of money involved. It takes about 10 lakhs to build just one unit of house. This is excluding the cost of the land and other supporting infrastructure like roads, etc. If one were to do simple math to provide such infrastructure to even fifty thousand people, the sum goes up to billions making one question the rationale behind such schemes.

Slums come up in the cities because there is a demand for cheap housing near places of work or because of an absence of low-cost mass transit system that timely and effectively connects all points of the city. This absence leads to people spending more time in overcrowded systems leading to inefficiency and losses to the economy.

The administration has also failed to check the growth of slums that have occupied potential commercial spaces in the cities. Cheap housing and almost no restriction on starting an industry is what attract many to these areas. It is surprising to see how space is efficiently utilized to run several hundred production houses in a space smaller than an MNC's parking lot! They also provide low cost labor that is vital to maintain the economic competitiveness of the city.

Today, no Indian city appears in the top 100 cities of the world. New Delhi scores a 143rd position while Mumbai is at the 146th position. Though late, India can benefit from the advancement in technology and implement ingenious solutions to the challenges that cloud the growth of its cities today. Around 1, 20, 000 crores are required to upgrade road infrastructure that includes new

Top: Haphazard building of freeways will only benefit in the short term

Left: The administration has also failed to check the growth of slums that occupied potential commercial spaces in the cities

The administration has also failed to check the growth of slums that have occupied potential commercial spaces in the cities. Today, no Indian city appears in the top 100 cities of the world. New Delhi scores a 143rd position while Mumbai is at the 146th position.

flyovers, highways, freight corridors, terminals, etc. just to keep up with the current statistics of growing vehicular traffic.

It is imperative to understand that haphazard building of freeways and widening existing community roads will be beneficial for only the short term, since without planned infrastructure people would make trips that could otherwise have been avoided. With an inefficient public transport, the need for personal vehicles will grow even further. There is a need to reduce unproductive mobility. This can only happen when cities grow in a planned fashion.

For centuries humans have walked and our bodies are used to this form of natural mobility. The sudden spurt of mechanized mobility has caught it completely off guard resulting in innumerable health drawbacks. If schools, groceries, hospitals, parks, community centers and other essentials are located at a walking distance of maximum ten minutes, apart from its health benefits, it also greatly reduces unnecessary usage of personal vehicles thereby saving costly subsidized fuel and sparing the tax payer's money for a better purpose.

In the context of Indian cities, it may not be possible for the administration to take very radical steps to shift the current patterns of urban transportation but with simple and imaginative solutions, these issues can be re-visited more effectively. For example, by creating walkways between large city blocks we can interconnect them with every other block like a grid pattern. So, instead of going around a large block, one can walk or cycle through it reducing the usage of vehicles for short distances.

Creation of a network of free cycling options that allows anyone to pick up a cycle after paying a refundable deposit and drop off the same at any cycle stand dotting the city will have multiple benefits, which include boosting tourism too.

Prohibitive parking rates can then be implemented in the next phase for congested areas to divert parking to relatively less congested or planned parking spaces without shutting the main street completely for vehicular traffic.

Ground water availability in the urban areas has shrunk considerably in the past few years. This is largely due to vanishing greenery paving way for a concrete jungle. When it rains, water cannot pass through the cement and asphalt surface. So, it has to be drained using a sewage network. But replacing old sewage pipelines can be both expensive and cumbersome in a busy area.

There is a need to use permeable surfaces for roads and pavements that allow water to seep through, relieving pressure off the existing sewage lines or on the line of Curitiba city in Brazil, create a green corridor consisting of parks and water bodies in the city. This circle of greenway would naturally recharge ground water and encourage natural habitat in the neighborhood. Moreover, it provides a soothing experience as well as keeps the general temperature of the area down. As a consequence power consumption for air conditioning the offices and shopping centers will decrease in the region.

Runoff water from the roofs of buildings can be collected and channeled back to locally meet the demands of the community. Recycling water using biological solutions will save administration the huge sums it currently employs in managing it. This will also free up pressure from the reservoirs.

For centuries civilizations have been established around a source of water. It may either have been a lake, pond or river. Many Indian cities have such water bodies existing in their jurisdiction or passing through them. Unlike Bangkok, which developed an extensive network of water transportation, rivers in India have largely been reduced to filth-choked dribble -- open sewage channels through which thousands of cubic liters of waste water flow into the rivers everyday. But what if such channels could be used for transport?

River channels can be developed to promote transportation

Today we need to build cities that are smarter, that conserve energy, are pleasant to live in and easy to operate. The success of any city depends largely on seamless travel for its citizen from one point to another as efficiently as possible.

If the waters from major feeder pipelines could be cleaned before entering the main channel, we would have waters that are clean enough to be used for water transportation. It can be an alternate mode of transport for people residing in areas which have low or no connectivity to public transit system but have a channel flowing nearby. Water transport costs 1/6th of ground-based transportation and so benefits the poor and also keeps our water bodies clean.

Since these channels drain into a river, we will have a seamless connection giving scope for even intercity travel and trade. With an active transportation link in the backyard to other commercial points of the city, valuation of properties around the banks of these channels, which are today considered worthless, will improve considerably. A win-win situation for all!

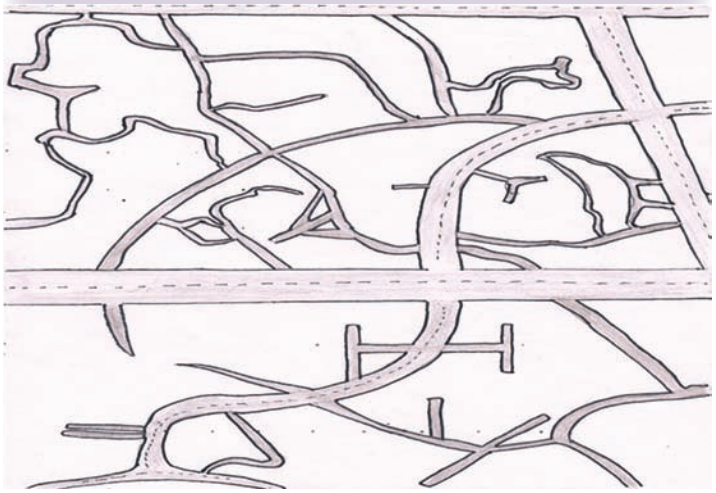
We must understand that land is a finite resource which has to be shared equally. Therefore, we must adopt sustainable development that includes creating spaces for people and not cars. Allowing random growth of cities and townships has resulted in chaotic network of roads.

When large settlements are allowed to be built in an unsystematic manner around a carriageway it results in community roads that end abruptly or randomly curve seeming unsure of where they intend to proceed. This pattern reduces the number of alternative routes available for motorists which would otherwise be available in a grid-like pattern. As a result there is heavy dependence on a single road which if laid in arbitrary order can further hamper speed severely decreasing its traffic carrying capacity. It is interesting to note that the average speed of a vehicle in a city today is around 8 km/hr.

The success of any city depends largely on seamless travel for its citizen from one point to another as efficiently

Unplanned development leads to chaotic traffic

This form of chaotic growth severely reduces the number of alternative routes possible for a road user resulting in heavy dependence on main carriageways.



Transport systems need to be integrated

There is an immediate requirement for planned infrastructure that is sorely lacking today in most cities of our country.

as possible. It is wise to implement mass transit solutions like BRTS, trams or metro rail in cities with high densities of people. However, it is more important to integrate them. Today most of these systems function independently in our cities resulting in long hours of travel time which ultimately leads people to opt for the relatively convenient personal vehicles.

These systems have to be integrated keeping in mind the ground reality of the user. For example, a commuter wanting to travel from point A to B requires him to take a metro whose station is located a few blocks away; he should know when the next train would be and also the connecting mode of transport to reach there. If buses/trams are scheduled to seamlessly integrate with that of metro and through a single settlement system which allows the consumer to pay for multiple services, the user would spend less time in buying tickets or waiting and travel faster to his/her destination.

Frequencies could be altered depending on the density of the commuters thereby making the system more efficient. Planned infrastructure allowing availability of taxis, cycles, and automatic personalized vehicles to cover the last mile to reach ones' destination will drastically reduce the need for people to own vehicles.

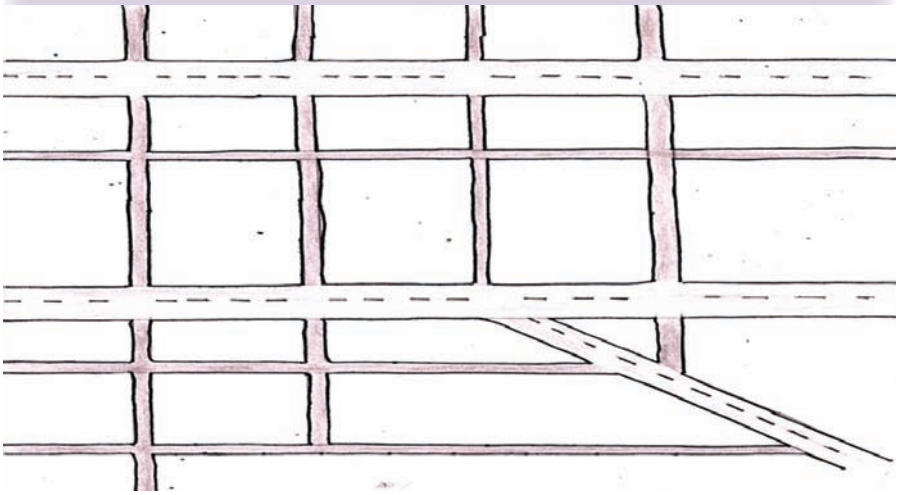
We need to focus on Transit Oriented Development (TOD) and build compact, dense and vertical urban centers that will push for efficient mass transit systems and encourage cycling and walking. The cost of not doing anything can be enormous. Allowing the cities to grow in an unplanned manner will result in severe environmental degradation. This also has an incalculable economic cost. Building massive freeways can only be a short term solution to serve the needs of residents residing in settlements built by developers far away from the city that cater only to their private vested interests. Communities must be designed keeping in mind the larger interests of the society.

Cities are not just concrete blocks. They are about people living in an interactive environment. Streets are places of primary social interaction between people. It's where the society builds trust. They have to be lively with activity and greenery. Design should be simple and elegant.

Today we need to build cities that are smarter, that conserve energy, are pleasant to live in and easy to operate. The cities should be about sustainability and not adaptability. Its citizens should go on to live their lives the way they want to and not have to strain themselves adapting to it.

If we want to make lives happier for people, let's make our cities better.

An organized settlement will have several alternative routes allowing motorists to avoid using the main carriageway.



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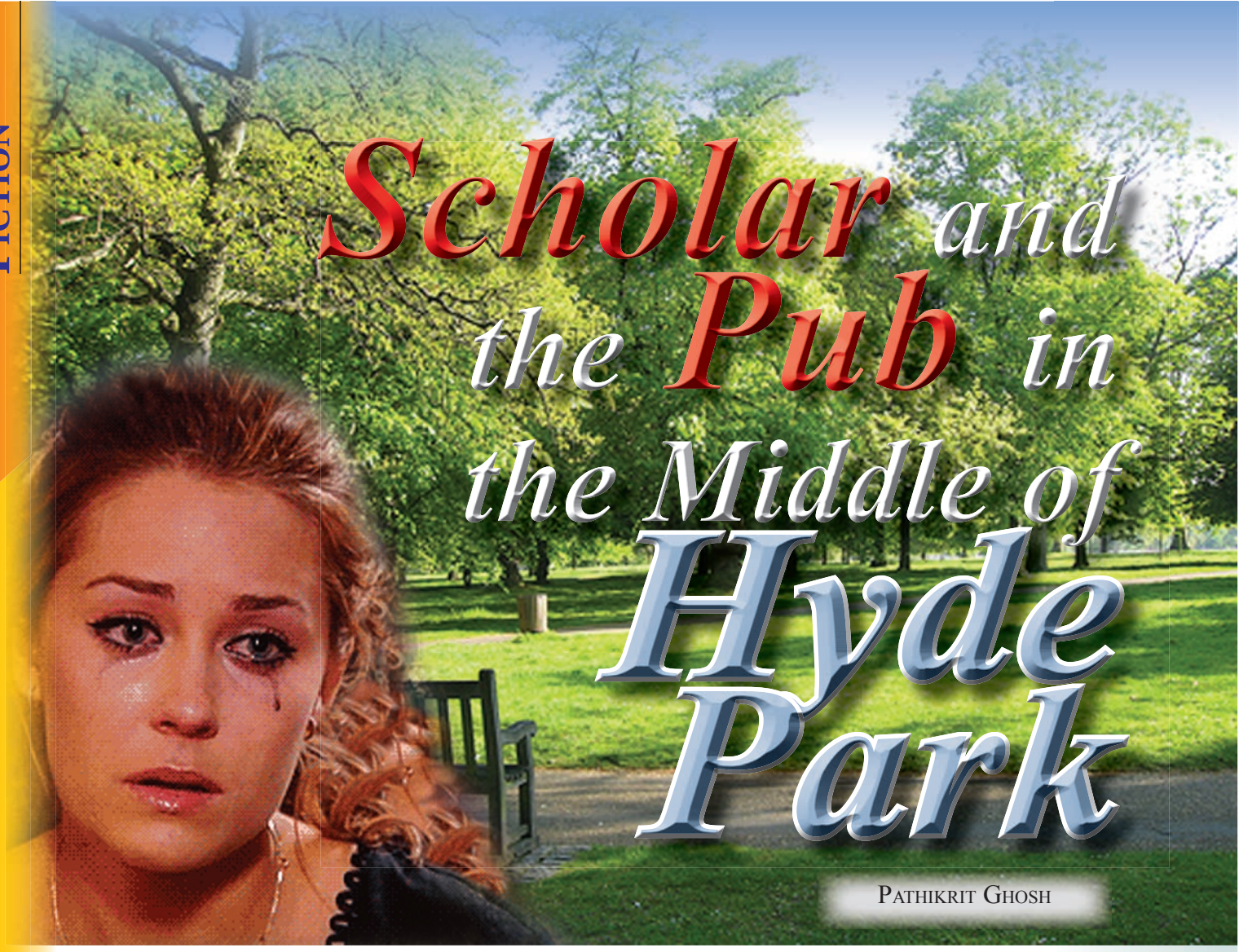

Scholar and the Pub in the Middle of Hyde Park

Pathikrit Ghosh

THE clipping file in her clutching embrace hurt her terribly. She concluded her scientific career had collapsed even before it had started. Haven't we all had these phases before?

It was just like being nine – when all she wanted was to be the next Ronaldinho. Then injury, talent, and the irrevocable decision made by destiny to be born as a girl, eradicated her hopes of playing in the Premier League. The same way her dreams of being an actor, or a paradigm-shifting scientist, would only lie sha*ered before her, on whose sharp, painful edges she would have to step over to move forward. It is nothing new; it has happened before.

Her dreams, she thought, would continue to break till one day she would jerk awake, and remain so, till she found her final resting place. Dreams are for fools, she thought. And she moved forward, with little tears gliding down her smooth cheeks, rose-red in the frosty colds of late autumn in London.

She had presented her findings to the Imperial College of London – where they decided on cutting short on funding superfluous projects. In fact, they said, that as her work was of no immediate industrial consequence, and was burdened with no signs of tell-tale progress, she had to do her own funding.

"Who wants stupid quantum electrodynamics?" she screamed to her invisible sympathizers floating in the air, whose patronizing gaze was jut too much to bear. She adjusted her overcoat, wrapping it so that the biting wind became toothless, and she hurried on.

Dejected and sad, Sofia Ivanovna walked away aimlessly on the streets of West London, till she came back to the same square, and looked towards the southern entrance of the Hyde Park. She wanted to be alone with herself, and her morose future. And even though the cold kept people huddled, the bright lights lit the stony paths that led away from the busy London life of continuous movement, symbolized by the iconic London's Eye. She amused herself with such thoughts, and she walked forward.

The journey through the Western Carriage Street, which divides the Kensington Gardens and the Hyde Park, should have been at most twenty minutes, a) er which Sofia would have found herself at the Lancaster Gate, where she could take the Tube. But a) er almost thirty minutes, she realized that something was clearly amiss.

The lights in the skies were less orange, and the stars glimmered brighter. The flood of light cause by the fluorescent streetlamps had changed to the warm glow of yellow incandescent bulbs. Surely, this was the older part of the Park? May be she was headed towards the Marble Arch, or the Upper Grosvenor Street?

She continued to wonder in silent amazement, until she realized that there was no traffic noise. Even for ten thirty in the night, the park was frigh=ully quiet. The phantoms of the London's past were suppressing her depressed mood, but then she spotted that little pub straight in the middle of a dark grove, with the streetlamps making an arched entrance look brighter than it

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actually was. There were people inside, though; she sought refuge from her own solitude.

She pushed open the door to find a dimly lit, smoke curtailed bar, with qite a few of people inside, and old music playing, a particular song that she could not find out. She went quietly to the bar, sat down with her heavy expression, while the bartender approached her with his curious countenance. "Just water please", she said, and he nodded.

Glancing around, she saw the twenty other odd tables, filled with people who look ed equally grim, maybe sometimes surrounded with a smokescreen of exhaled tobacco puffs, through which you could see the gleaming red pipes, and their owner's concerned faces. She could overhear the only two tables without the smokescreens. One was discussing the cancelled League Cup matches, and the other was discussing serious physics.

"I am pre* y sure that these self-sustained reactions that these chemists speak of are nothing but trifles. No ma* er what the Swedish Academy thinks. Also, in all this time I am fleeing persecution, I have not been up to date with anything going on in Cambridge."

"I can understand," the other gentleman replied.

"But, I am really concerned with all the flak Quantum Mechanics is ge/ ng with the publication of this paper by Mr Einstein, that so called EPR paradox?"

"Yes".

"How do you resolve that? I cannot think of anything right now! This is just too much! Even while I am running I am thinking of that!" The man said with his odd accent breaking his sentences. He was clearly German, and not very used to speaking English.

"I think we need to wait, and..." he began very timidly. Then, after waiting few minutes, he said, "there may just be some hidden variables that we still don't know."

"There are no local hidden variables," Sofia said. It ostensibly disturbed the two gentlemen. "I am sorry to bother you, but I don't generally get to hear physics being discussed over at pubs. Might I join in the discussion?"

"Of course, we.." began the English gentleman, but then stopped. He looked too startled.

"We were discussing about the Einstein, Podolsk y Rosen paradox, that they have published," the German gentleman said. "I have no idea how to resolve it. I cannot even talk with him now, that I have said those awful things in Vienna. They forced me to dismiss the ideas, and reinforce Nazism."

"Okay," said Sofia, "The EPR Paradox is not a paradox at all. In fact, we can use it to make what we call Quantum Entanglement. Both particles have the same wave equation, and because of the conservation laws of momentum and spins, we can find out the spin of one particle if we know the spin of the other particle, almost instantaneously."

"That is precisely what EPR says we cannot!"

"But that is because no amount of local hidden variables, or any theory based on them can ever reproduce quantum mechanics!"

"UNBELIEVABLE!" screamed the English gent. "Unbelievable! Do you have a theory supporting your views young lady?"

And for the next twenty minutes, Sofia took out the frustrations of her scientific life on these, what seemed to her, amateurs. She didn't explain all of it correctly, and she thought, the English guy looked a bit lost at the end of it.

"HAHAHAHA", the German started laughing. "And, bless me! I thought I had seen it all. Well, I must leave now. I need to see if I can afford the Political asylum. Good night, lady and Paul!" He went out of the pub laughing wildly.

"I want to see you at Cambridge. It will be an honour to talk with you. If, I may be so bold...can I know your name?" the English gent asked.

"Of course, it is Sofia"

"Good night, Sofia"

He went out as well, Sofia, however, had a very strange feeling: the feeling of something being out of place.

"Boy, you scared him bad," the bartender said, ge/ ng her a glass of gin.

"Do they meet quite o) en? Those two gents?" she asked in return.

"No. But I know who they are, though I am pre* y sure they forgot to introduce themselves. The german speaking gent, he is Erwin Schrodinger. And the other gent is Paul Dirac. I am pre* y sure you know them as the recipients of the Nobel Prize together."

She spilled her drink, and started coughing with excitement.

"P.. Paul Dirac? Schrodinger?" She couldn't understand. "What? How? Is that some costume party by those Oxford geeks? What time is it?"

"It is five minutes past eleven o" clock in the night, of 21st October 1940."

She brushed her fingers through her hair, pulling it back, as if it would help her understand her surroundings be* er. "What... I do not get you. Are you positively sure?"

"Yes, ma'am. I am positively sure."

She stumbled towards the door, but instead of going to the one leading outside, she broke into another room. This one had twenty odd tables, and the lighting had changed to candles lit in the alcoves of the bar, and ornate candlesticks adorned the tables of the bar. They were lit, and a magnificent aura had descended into that room. She entered, looking distractedly through the room, searching for one single piece of evidence that this was only a themed restaurant. But no, she couldn't see a single switch, or a wire. This was clearly something different. She thought, she was going back into time, or descending into madness and hallucinations.

"So James, I must congratulate you!" said a portly man with a gigantic beard, as regal as his companion's, in an unformed Lancashire accent. "Your discovery, and your equations, such excellent work!"

She had presented her findings to the Imperial College of London – where they decided on cutting short on funding superfluous projects. In fact, they said, that as her work was of no immediate industrial consequence, and was burdened with no signs of tell-tale progress, she had to do her own funding.

"I thank you, Mr Joule. I assure y'e, all we need to kn'w now are the prop'rties of this Space ether," his companion replied.

"Indeed, my dear fellow! It seems we have discovered all that there is to know in physics!"

"No!" she screamed. Everybody started looking at her. "Abandon your concept, Maxwell…Sir Abandon it! You think you know everything? You know nothing, James Clerk Maxwell!"

She couldn't understand why this was happening, in fact, she didn't know what was happening. She rushed through rooms a) er rooms (she thought she saw Charles Dickens) until she found that the rooms weren't changing their lightings. A seat was empty at the bar; she sat down on it, next to a gaunt looking man with beady eyes, with a cloud of sadness around him. Familiar company, she thought.

She ordered nothing in particular to a waiter who looked exactly like the one in the first room. "I am a little lost" she said.

"Aren't we all?" the man replied.

"I am sad and depressed, as well."

"It is the same for me. Oh this cruel world! The natural world is being replaced by an artificial one. And no one is interested to know about the Natural Sciences! It seems that even a) er achieving considerable acclaim in geology, my new ideas are not being approved. Do you like Natural Sciences, young girl?"

"I do. I study physics."

"Then, would you be astonished to k now that I think we evolved from some common ancestor we shared with Chimpanzees and Orangutans? Do you think this idea is difficult to believe? For normal people? Tell me honestly, and tell me the truth."

"No. It is a truly paradigm changing idea. Would you believe I came from the future?"

"It is that farfetched? I see. No one wants this idea. But, science isn't about what one wants or not – it is about discovering truths. It is about what nature wants us to know. So what if my experiment is a failure? I am sure, woman of the future, that someday, someone will come to the same conclusions as the naturalists. Nice to meet you, I am Charles Darwin. At least you heard me out."

"It was a pleasure Mr Darwin. I am Sofia Ivanovna. I think your work is splendid; you shouldn't give up on it! You should publish; you should let other people know. I am pre* y sure, they will end up with their own independent conclusions similar to your own."

"I think it is all useless! They will not fund me! They will not let me live this way! The animosity some members of the general public have shown, oh god! It is awful!"

She looked up to him. Even for his paradigm changing idea, he faced a genuinely distressful opposition. His eyes were red, and little drops of tears lingered on his eyebrows before falling down. "You should put your best foot forward. Then, if your theory survives the test of observations, it will persist. Until some other person comes and gives a be* er theory. Yes, that is Natural Selection. I think you should go for it. At least publish it, find some good friends, and name it" On the origin of species". "

"You really are from the future?" Darwin asked astonished.

"Yes sir, I am."

"I am bewildered. But, even though it is a prank. I cannot thank you enough. I will start working as soon as possible. I did not go through all that voyaging around the seas just for fun. For the progress of humanity! We need to know where we came from! For Science!"

She watched him hop off the stool, at the bar, and walk away. "Sir" she called a) er him. "Sir, I wanted inspiration from you. My research just got cancelled."

"Oh! But, inspiration, you have already Sofia Ivanovna! For science! That is the greatest inspiration of all! For science we endure all these hardships. What more a noble pursuit do we have in life? You answered your own question."

"Thank you, Mr Darwin. Sir", she called a) er him once again. "Your eyes. They won't win you many friends."

"So won't my theories. But like I care!"

Sitting for five more minutes, she decided to go through the door of the room once again. Only this time, she stepped into broad daylight.

"Death to Copernicus! Death to Copernicus!" A motley mob, with pitchforks and flaming torches went about. She looked behind him, only to see the pub gone. She knew she couldn't go back now. So what had she to lose? Curse that wormhole, she thought. "For science!" she ran towards the mob, her arms flailing, and her voice screaming at them to stop and listen to Copernicus's theory., She wanted to defend it, no ma* er what cost her. For science. Yes, that is what all this was for! What all these great men and women sacrificed their lives, and faced such opposition!

"Silence! Get her!" All round her, swords were pointed. "Take your words back, woman!"

"I won't! The earth is moving around the sun!"

"She had her chance! Off with her head!"

She did not close her eyes, but the reflex did close it for her. She could feel the cold metal of the blade cut through the skin of her throat…

…she awoke to the bright morning sunshine, and touch of a police baton. "Enough of this! Get up, girl!" The policeman prodded on, and then went away on his rounds, shaking his head on today's youth.

She woke up, dazzled from her dream. "Well", she thought, "even without the scholarship, at least, I still have my head on!" That should be enough for science.

Contributed by Pathikrit Ghosh, Q 124/3, SEC Railway Colony, Mount Road, Sadar, Nagpur-440001

Prize Puzzle

NAME THE INVENTOR

Here are a few inven$ons that were named a7er their inventors. Can you name the inventors of each of these inven$ons?

1. Diesel engine :_____
2. Foucault pendulum :_____
3. Bunsen burner :_____
4. Colt revolver :_____
5. Ferris wheel :_____
6. Fresnel lens :_____
7. Petri dish :_____
8. Wheatstone bridge :_____
9. Kalashnikov :_____
10. Gillette safety razor :_____

There are three prizes of Rs 500/- each for three correct entries. In case of a large number of correct entries, the prize winners will be selected through a draw of lots. The decision of the Editor, *Science Reporter* will be final.

Send your entries to:
Puzzle Corner
Editor, *Science Reporter*
National Institute of Science Communication & Information Resources (NISCAIR)
Council of Scien$fic and Industrial Research (CSIR)
Dr KS Krishnan Marg, Pusa Campus
New Delhi-110012

Last date for the entries to reach us: 05-2-2015

Name : .....
Address : .....
.....
..... Pin code: .....
Age : ..... Email: ..... Sex: .....

Occupa$on : ☐ Student ☐ Housewife ☐ Teacher ☐ Professional ☐ Re$red ☐ Other

Educa$onal level : ☐ Primary ☐ Secondary ☐ Graduate ☐ Postgraduate

- *Please fill up the questionnaire at the back*
- *You can send your answers on a photocopy of this page as well.*

FIND THE NUMBER

Find the four-digit number designated by asterisks, given the following:

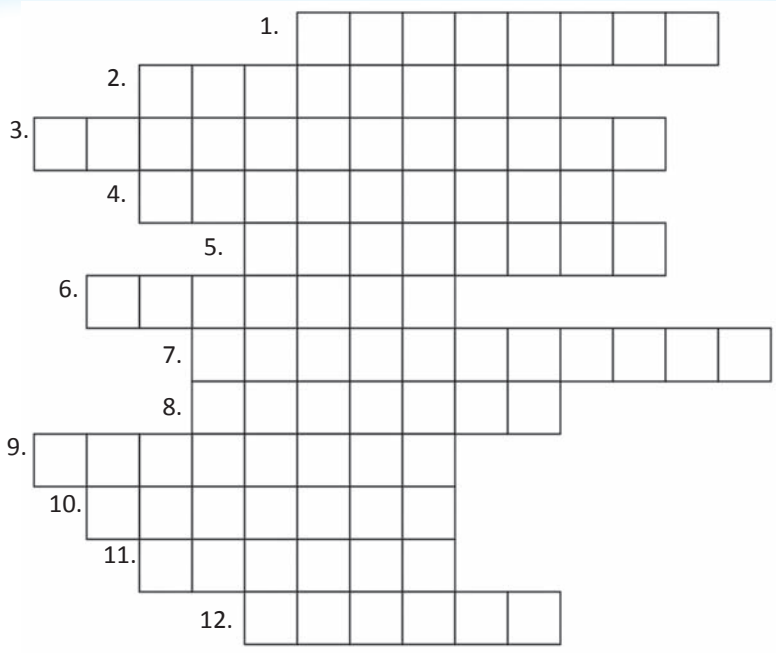
- All four digits of the unknown number are different.
- None of the digits is zero.
- Each "0" on the right of each four-digit number below indicates that the number has a matching digit in a non-matching position with the unknown number.
- Each "+" on the right of each four-digit number below indicates that the number has a matching digit in a matching position with the unknown number.

```
6152  +0
4182  00
5314  00
5789   +
-------------
****
```

BACTERIAL DISEASES

CLUES

1. Clostridium botulinum causes this food-borne disease
2. Toxin of a species of clostridium provoke uncontrolled contraction of the muscles leading to lock-jaw
3. Mantour test is done for this lung infection
4. Corynebacterium sp. is the causa$ve agent for infection near tonsils
5. Whooping cough is another name for this disease
6. This bacterial spores can be used as biological weapon
7. Dysentery caused by shigella sp.
8. Rice water stool is caused by this disease
9. Treponema palladium causes this disease through sexual intercourse
10. This disease is also known as Hensen's disease
11. Yersinia pes$s is the causa$ve agent for this disease
12. Widal test is carried out to detect this disease



Contributed by Dr. K. Venkataraman, A-T-2 Porkudam Apartments, Bypass Road, Madurai-625010

Solutions to the puzzles published in the November 2014 issue

Prize Puzzle:

DISEASE PUZZLE

Lung	Eye
Spleen	Leg

WHO AM I?

DEUTEIRUM
PROTON
NEUTRON
GRAVITY
CALORIE

MARTIAN CRATERS SEARCH

E:	Cassini, Kepler, Schiaparelli
NE:	Pasteur, da Vinci, Jeans, Galle
N:	Hooke, Henry, Pickering, Haldane, Gale
NW:	Huxley, Airy, Hale, Herschel
W:	Mendel, Reynolds, Wien
SW:	Bok, Curie, Wegener
S:	Barnard, Copernicus, Newton, Russel, Lowell
SE:	Huygens, Jones, Brahe

The prizewinners based on the draw of lots from among the correct entries are:

- **Ms Jennathul Henna**
  E.P., Edathinapuram House,
  KavaraJ Island,
  Lakshadweep-682555
- **Karan Agarwal**,
  118/241 Kaushalpuri,
  House No. 3, Gum$ No. 5,
  Kanpur-208012
- **Raashid Jamal**,
  Nana Sahab ka Bara,
  Bazariya, Dholpur,
  Rajasthan-328001

Congratulations all the winners!

SCIENCE PROJECT

Estimating Tree Cover in Mumbai

Figure 1: Satellite Image of Mumbai

OUR environment is under constant threat due to various activities that are aimed at extracting resources with gay abandon. Constant logging is depleting rainforests, fossil fuel consumption is leading to global warming and poor farming methods have robbed the soil of its nutrients. We need to understand the extent of this change so that we can act before it is too late.

One very valuable data is the percentage of tree cover in a particular area. This gives an idea of the change that has happened in a place in terms of development as well as destruction of the natural environment.

Mumbai is a city that has undergone drastic change in terms of development and also tree cover. In an attempt to find the actual tree cover, I used probability to find the approximate percentage of area in Mumbai that is covered with trees.

Methodology

I used the satellite images of Mumbai to get the data required for this study. Using 'Paint', I first made two gridlines across the satellite image. The intersection point of the gridlines in Mumbai and the total number of intersection points was tabulated as '1' for the first reading. I then looked at the intersection point and ascertained whether it lay in the green patch of land, indicating tree cover, or not. After having determined this I tabulated that it did not lie in the green cover and so no intersection points passed through the tree cover. Using this I found the probability if I placed "one" random point on the image (in Mumbai) of it landing on tree cover.

The general formula used was:

$$\text{Probability} = \frac{\text{Number of Intersection points of the gridlines in Area of Tree Cover}}{\text{Number of Intersection points of the gridlines in Mumbai}}$$

This method was repeated for different numbers of intersection points and the data obtained is presented in Table 1 along with a satellite image of Mumbai that was used:

TABLE 1

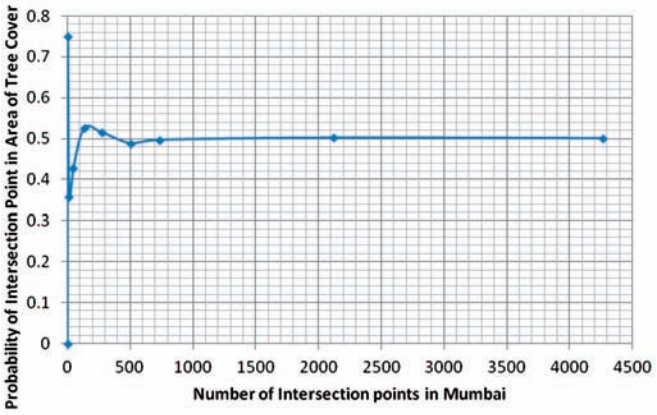
Number of Intersection points in Mumbai	Number of Intersection points in Area of Tree Cover
1	0
4	3
14	5
49	21
135	71
276	142
506	247
737	366
2124	1066
4267	2135

TABLE 2

Number of Intersection points in Mumbai	Number of Intersection points in Area of Tree Cover
1	0
4	0.75
14	0.3571
49	0.4286
135	0.5259
276	0.5145
506	0.4881
737	0.4966
2124	0.5019
4267	0.5004

Table 2 shows the data and the Graph 1 obtained of the number of intersection points and the probability of the intersection point being on the tree cover:

GRAPH 1: PROBABILITY DIAGRAM FOR PROPORTION OF TREE COVER IN MUMBAI



The satellite image could not really detect every tree, but could only detect those areas where there was high tree density. So only those areas would show up on the map where there were a lot of trees in one place.

Another important thing to note about the tree cover in Mumbai is its density. In some parts of Mumbai, such as in the National Park, the tree cover is a lot denser whereas in some parts such as southern Mumbai the tree cover is close to nil.

Analyzing the Data

From the data obtained above, it can clearly be seen that the area of tree cover is approximately half the area of Mumbai. The values hover around a probability of 0.5 as can be seen from the graph. Also, for smaller values of intersection points the probability is quite far off from 0.5, but as more numbers of intersection points are taken the probability of the points becomes nearer to 0.5. Using the weak law of large numbers we can say that the probability of the random point placed in Mumbai will land on the area of Tree Cover approximately half the time.

Thus, the values on the graph stabilize for higher number of intersection points as this improves the reliability of the experiment. Another important thing to note about the tree cover in Mumbai is its density. In some parts of Mumbai, such as in the National Park, the tree cover is a lot denser whereas in some parts such as southern Mumbai the tree cover is close to nil clearly showing the areas that have undergone development and those that have not.

Limitations of the Method

The method that was employed for calculating the probability of the area of Tree Cover in Mumbai was a crude method and not perhaps the most exact method of calculating the area although it did manage to give a fairly good estimate of the area, especially for higher number of intersection points. There were a few limitations to the method:

1. The image used was a satellite image, and in the image all the green cover was assumed to be tree cover, although a portion of that cover may have indicated other things like lakes. So the results obtained were only a rough estimate of the actual probability.

2. The satellite image could not really detect every tree, but could only detect those areas where there was high tree density. So only those areas would show up on the map where there were a lot of trees in one place.

3. What were used for the purpose of the experiment were intersection points. Although such a large number of intersection points were used (4267), the margin of error in the area indicates that the actual area could have been slightly different as has been calculated above, thus not giving the exact value.

4. It is a fairly tedious and long drawn method that takes considerable time to calculate the number of intersection points especially for larger number of intersection points. This is a method that can only be applied to, say, a city but not on a macro scale as it would be too time-consuming. Instead, software can be used to find the probability but this would compromise on the understanding of the maths behind the calculation of the margin of error.

The intersection point of the gridlines in Mumbai and the total number of intersection points was tabulated as '1' for the first reading.

Even though the experiment and methodology had limitations, it is still a fairly accurate measure of the area of tree cover in Mumbai.

Green Cover in Mumbai

Area of Greater Mumbai: 437 km2 (Civic diary of the Municipal Corporation of Greater Mumbai)

Area of Sanjay Gandhi National Park: 104 km2

Area of Sanjay Gandhi National Park in limits of Greater Mumbai: 80km2

Area of mangroves: 37 sq km; 40% reduction in mangroves = 25 km2

Total no of trees (2008 census of Garden department of Municipal Corporation): 19.17 lakhs

Less 1.59 lakhs shrubs and also less 0.33 lakhs dead trees = 17.23 lakhs, which can be taken as 17 lakh trees

Area of canopy of one mature tree (assumed) 10 m in diameter, so area of canopy =

$$\frac{\pi}{4} X(10 \times 10) = 78.5 m^2 \approx 70 m^2 \text{ taking the lower bound}$$

Total area covered by trees (canopy area looking from top) $= \frac{1700000 \times 70}{1000 \times 1000} = 119 \text{ km}^2 \approx 120 \text{ km}^2$

So, green cover with Sanjay Gandhi National Park + Mangroves + Tree canopy area = 80 + 25 + 120 = 225 km2

Therefore the percentage Tree cover is $\frac{225}{437} \times 100 = 51.48\%$

Without Sanjay Gandhi National Park: 25 + 120 = 145 km2

Therefore, the Percentage Tree cover is $\frac{145}{437} \times 100 = 33.18\%$

Without Sanjay Gandhi National Park and Mangroves = 120 km2

Therefore, Percentage Tree cover is $\frac{120}{437} \times 100 = 27.46\%$

This goes to show that the obtained value in the experiment of 50.04% is very close to the literature value of tree cover and differs by only 1.44%.

Master Devansh Jalota is studying in 12th Grade in the Dhirubhai Ambani International School in Mumbai. Address: 31-Amber, Narayan Dabholkar Road, Malabar Hill, Mumbai-400006; Email: devansh.jalota97@gmail.com

GAFFGUN

GaffGun is a solution to messy cables. It automatically brings together all of the cords, straightened and lays down the tape and ensures no one will accidentally be tripping or ripping out your cables. This uses CoreLok technology i.e. different sizes of guides available for different sizes of cables. It is a gadget that can take hardly 2-5 minutes to secure a few meters of cable in a neat and tidy fashion. The creators of GaffGun said that it is a time saving tape packaging dispenser that tapes down the cords 96% faster. The device is designed to make the job easier who worked in film/ television production, special events set up and in other similar industries. (www.prosoundweb.com)

BLU-RAY DISCS CAN MAKE SOLAR CELLS MORE EFFICIENT

Despite the high capacity, high definition and higher transfer rate, researchers claim that Blu-Ray discs also have the ability to help in improving the efficiency of solar cells. Solar cells become more efficient at trapping light having quasi-random pa: erned surface, the pa: ern found in Blu-Ray discs. Researchers create a negative mold of the disc's nanostructures by pouring polydimethylsiloxane (PDMS) plastic onto a Blu-Ray disc (the disc was Police Story 3: Supercop). Then they used the mold to stamp the nanostructure pa: erns on to the surface of new solar cells to give them the same etching. The Blu-Ray imprinted solar cell showed a 21.8% increase in light absorption compared to non pa: erned solar cell. (www.livescience.com)

STACK'S SMART LIGHT BULB

The device reads room conditions and adjusts its lighting accordingly without any effort by the user. The bulb is embedded with sensors, microcontrollers, Bluetooth, Zigbee and iBeacon hardware allowing it to react autonomously once installed. During its installation owner is asked to specify whether it's for home or commercial use via app. Then, the bulb responds dynamically based on the time of day and location without the need for constant app-based interaction. It starts with cooler white light in the morning and gradually switches to warm colors when it's late. It will also dim or shut off the

SNAPJET PRINTER

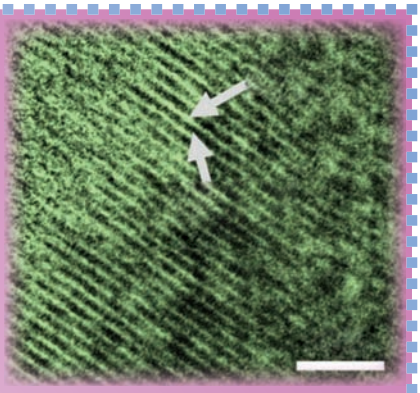
SnapJet is the world's first open-source instant film printer that prints photos from your smartphone's screen. It does not require any ink, Wi-Fi, Bluetooth, cables and special app. It is actually a miniature printer/scanner combo. The heart of a SnapJet is a micro-structured optical polymer that scans across the screen and transfers the image to the instant film. It will also be compatible with wide range of smartphone including iphones and android phones. The company claims that it can achieve Retina-quality prints of smartphone photos with a theoretical resolution limit of 1200dpi. (omnifeed.com)

KEYS-TO-GO

The Keys-To-Go is a light and thin keyboard that can easily be tucked into a briefcase for easy transport. The device is 0.24 (6 mm) inches thick and weighs a mere 6.35 ounces (180grams). It is a Bluetooth keyboard with iOS shortcuts available in three colors-red, black and teal. The keyboard will last up to three months on a single charge. The a: ractive part of key-to-go is the FabricSkin that wraps a full set of mechanical keys and makes it resistant to spills and dirt. There's no number pad, so all of that space is used to accommodate traditional keys and a few iOS shortcuts. It is an ultraportable, fit anywhere and go everywhere keyboard.
(www.logitech.com)

light when there is lot of light or you have leD for work. It is also an energy saving device – saves between 60 and 80 percent compared to regular LED bulbs.
(www.engineering.com)

NEW ELECTROLYTE FOR DEVELOPMENT OF MAGNESIUM-SULFUR BATTERIES



Scientists are currently studying alternatives to replace lithium with other elements in order to enhance the safety, cost efficiency, sustainability and performance of future devices. In view of this magnesium-sulfur ba: ery, which combines a magnesium anode with sulfur cathode, is a promising electrochemical couple. Besides its non toxic nature, magnesium is abundant in nature, low degradation in air and higher storage densities can be achieved than with lithium. A research team has presented a new electrolyte for the development of magnesium-based ba: eries. The electrolyte has a very high efficiency and can be used in various solvents at high concentrations. Also, it is chemically compatible with a sulfur cathode. For the production of electrolyte two commercially available standard chemicals, magnesium amide and aluminium chloride, are added to the desired solvent and subjected to stirring. This mixture can directly be used as an electrolyte in the ba: ery.
(www.researchgate.net)

FITBIT'S NEW FITNESS WEARABLES

Fitbit recently lifted the lid on its new fitness trackers: the Fitbit Charge, Charge HR and Surge. The fitbit charge tracker has the ability to track steps, distance, active minutes and calorie burned. It also features an OLED display which gives the information regarding time of day, exercise mode and daily fitness stats. The Fitbit Charge HR uses the same form-factor as the Fitbit Charge, but features a heart rate sensor for continuous heart rate tracking from the wrist. Fitbit surge – a fitness super watch – has loads of sensors and smartphone notifications too. With heart rate tracking, it also features a built-in GPS and the ability to get caller ID, text messages and wireless syncing. Ba: ery life is 7 days for charge, 5 for charge HR and surge on a single charge.
(www.theverge.com)

Essential Human Body Parts

SAROJ KUMAR PUJHARI

1. Choose the stato-acoustic organ in human beings:
a) Eye b) Nose
c) Ear d) Tongue

2. A human body part secretes hydrochloric acid but it is not burnt, identify it from the following:
a) Small Intestine b) Stomach
c) Large intestine d) Oesophagus

3. What provides nutrition to developing spermatozoa?
a) Sertoli Cells b) Interstitial Cells
c) Germ Cells d) All of these

4. Find the tissue originating from all three germ layers:
a) Connective Tissue b) Epithelial Tissue
c) Muscular tissue d) Nervous Tissue

5. The outer layer of cerebral hemisphere is also called:
a) Neopallium b) Neuropallium
c) Nervopallium d) None of these

6. A band connecting muscle to bone is called:
a) Ligament b) Cartilage
c) Connector d) Tendon

7. Name the funnel at the free proximal end of fallopian tube:
a) Infundibulum b) Isthmus
c) Ampulla d) Fimbriae

8. What do we call the blood vessel carrying blood away from heart?
a) Vein b) Capillary
c) Artery d) All of the above

9. Adam's apple in the neck of humans corresponds to which part?
a) Thyroid gland b) Pharynx
c) Trachea d) Larynx

10. Pace maker is associated with which organ?
a) Lungs b) Heart
c) Stomach d) Brain

11. The development of human embryo occurs inside which organ?
a) Uterus b) Ovary
c) Fallopian tube d) Placenta

12. Locomotion is the gift of which of the following cells?
a) Hepatic Cells b) Gastric Cells
c) Muscle Cells d) Nerve Cells

13. What is the second vertebra of human vertebral column called?
a) Coccyx b) Axis
c) Atlas d) Sacral

14. Which of the following is the unit of urine formation?
a) Neuron b) Urinary bladder
c) Ureter d) Nephron

15. The study of which organ is referred to as osteology?
a) Bone b) Kidney
c) Blood d) Brain

16. Which region of human nasal chamber is lined with schneiderian membrane?
a) Vestibular region b) Olfactory region
c) Respiratory region d) Filter region

17. Which part separates the thorax from abdomen?
a) Abdominal septum b) Thoracic septum
c) Diaphragm d) Ribs

18. Identify the area of sharp colour vision in human eye:
a) Colour spot b) Green Spot
c) Red spot d) Yellow spot

19. Which organ secretes insulin hormone?
a) Pancreas b) Stomach
c) Placenta d) Pituitary gland

20. Which endocrine gland is called emergency gland?
a) Thyroid gland b) Parathyroid glad
c) Adrenal gland d) Pituitary gland

21. Which part temporarily stores the faeces?
a) Duodenum b) Appendix
c) Ileum d) Rectum

22. Where do seminiferous tubules occur?
a) Ovary b) Testis
c) Seminal vesicle d) None of these

23. Find the blood bank of human body from the following?
a) Liver b) Bone marrow
c) Spleen d) Thymus

ANSWERS:

1. c	2.b	3.a	4.b	5.a	6.d	7.a
8.c	9.d	10.b	11.a	12.c	13.b	14.d
15.a	16.b	17.c	18.d	19.a	20.c	21.d
22.b	23.c					

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Symbols in Mathematics

BASANTA KUMAR DAS

1.= is the symbol used in mathematics very often, which is best known as:
a) Is Equal b) Congruent
c) So on and so forth d) Proportional

2. ≅ is the symbol for which of the following:
a) Equal b) Not equal
c) Similar d) Congruent

3. ∏ is the symbol for which mathematical language:
a) As b) Pi
c) Sigma d) Percentage

4. ⊆ is the symbol for:
a) Set b) Subset
c) Superset d) Null set

5. ∈ is the symbol for:
a) Exponential b) Doesn't belong to
c) Belongs to d) Euclidean plane

6. ζ is the symbol for:
a) Differentiation b) Partial differentiation
c) Limit d) Integration

7. ∴ is the symbol for:
a) Therefore b) Because
c) As d) So on and so forth

8. ⊃ is the symbol for:
a) Set b) Subset
c) Superset d) Proper subset

9. ~ is the symbol for:
a) Similarity b) Equality
c) Proportionality d) Inequality

10 ∞ is generally used as symbol for:
a) Similarity b) Infinity
c) Proportionality d) Empty

11. Δ is used as symbol for:
a) Symmetric difference b) Difference
c) Modulus d) Congruent

12. √ is the sign for:
a) Cube root b) Complex square root
c) Square root d) Inequality

13.√‾ is generally used as sign for:
a) Square root b) Modulus
c) Cube root d) Complex square root

14. ∝ is the symbol of:
a) Proportionality b) Equality
c) Inequality d) Infinity

15. % is the symbol of:
a) Division b) Multiplication
c) Percentage d) Equivalent

16. Σ is generally used as a symbol for big sum operation and this symbol is known as:
a) Sigma b) Pi
c) Tau d) Infinity

17. ... is the symbol for:
a) So forth b) So on and so forth
c) Congruent d) Inequality

18. ∉ is the symbol for:
a) Belongs to b) Equals to
c) Does not belong to d) Does not equal to

19. is the symbol for:
a) And b) or
c) Average d) End of proof

20. ≈ is the symbol for:
a) Equal b) Approximately equal
c) Therefore d) Unequal

21. $\overline{x}$ is the symbol for:
a) Average b) Implies
c) Greater than d) Very very large

22. ∧ is the symbol for:
a) And b) Or
c) Intersection d) Union

23. ||is the symbol for:
a) Absolute value b) Parallel
c) Approximately equal d) Equal

24. ! is the symbol used in mathematics for:
a) Division b) Rational
c) Irrational d) Factorial

ANSWERS:

1.a	2.d	3.b	4.b	5.c	6.d	7.a
8.c	9.a	10.b	11.a	12.c	13.d	14.a
15.c	16.a	17.b	18.c	19.d	20.b	21.a
22.a	23.b	24.d				

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Biodiversity Hotspots

MAYANGLAMBAM OJIT KUMAR SINGH

1. To qualify as a Biodiversity hotspot, a region must meet two strict criteria: it must contain at least 1,500 species of vascular plants as endemics, and

(A) it has to have lost at least 70 percent of its original habitat

(B) it has to have gained at least 70 percent of its original habitat

(C) it has to have lost at least 30 percent of its original habitat

(D) it has to have gained at least 70 percent of its original habitat

2. Name this British ecologist who defined the biodiversity hotspot concept in 1988 to address the dilemma that conserva! onists face: what areas are the most immediately important for conserving biodiversity? He is also known for his prominent work in – "The Environmentalist" and "HOTSPOTS – Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions".

(A) Ernst Mayr (B) Norman Myers

(C) P.Z Myers (D) M.G. Mayer

3. Over 50 percent of the world's plant species and 42 percent of all terrestrial vertebrate species are endemic to the combined area of the remaining habitat of Biodiversity hotspots which covers merely 2.3% of the Earth's land surface. How many Biodiversity Hotspots are known today?

(A)22 (B) 32

(C) 34 (D) 24

4. Which of the following regions has the highest number of the Biological diversity hotspots in the world?

(A) Africa (B) South Am rica e

(C) North and Central America (D) Asia Pacific

5. Name this Biodiversity Hotspot which is home to the greatest non-tropical concentra! on of higher plant species in the world. The region is also the only hotspot that encompasses an en! re floral kingdom, and holds five of South Africa's 12 endemic plant families and 160 endemic genera.

(A) Horn of Africa (B) Coastal forests Eastern Africa

(C) Succulent Karoo (D) Cape Floris- c Region

6. Guinean Forests of West Africa is the only Hotspot which hosts the homes to more than a quarter of Africa's mammals, including more than

(A) 5 species of primates

(B) 10 species of primates

(C) 20 species of primates

(D) 30 species of primates.

7. This Biodiversity Hotspot is one of the most geographically complex areas on Earth, with a diverse range of islands of varying age and development. Name this Hotspot which includes some 1,600 islands.

(A) Mountains of Southwest China

(B) The East Melanesian Islands

(C) New Caledonia

(D) The West Melanesian Islands

8. Which Hotspot has the world's highest mountains where vascular plants have been recorded at more than 6,000 meters?

(A) Himalaya

(B) Sundaland

(C) Central Himalaya

(D) Polynesia

9. Known not only for remarkable endemism in freshwater turtle species, six large mammal species have been discovered in the last 12 years from this Hotspot. Name this Hotspot.

(A)Indo-Burma

(B) Cambodia-Lao

(C) Philippines

(D) Thai–Lao

10. The Polynesia-Micronesia hotspot comprises of 4,500 islands and it stretches across the southern Pacific Ocean. This Hotspot is considered to be the epicenter of the current global ex! nc! on. Twenty-five bird species have gone extinct here since the arrival of the Europeans

(A) 300 years ago (B) 200 years ago

(C) 100 years ago (D) 10 years ago

11. Name this Hotspot which covers the western half of the Indo-Malayan archipelago, an arc of some 17,000 equatorial islands, and is dominated by two of the largest islands in the world: Borneo (725,000 km²) and Sumatra (427,300 km²). Orangutans are found only in this Hotspot.

(A)Caucasus (B) Indian Ocean Islands

(C) Sundaland (D) Sumatra

12. The flora and fauna of this Hotspot are so varied that every island in this hotspot needs secure protected areas to preserve the region's biodiversity. The world's largest lizard, the Komodo dragon is also found only in this Hotspot. Name the Hotspot.

(A) Southwest Australia (B) Philippines

(C) Japan (D) Wallacea

13. This Hotspot houses important popula! ons of Asian elephants, Indian ! gers, and the endangered lion-tailed macaque. Name this Hotspot which is also extremely rich in endemic freshwater fish with over 140 na! ve species.

(A) Western Ghats (B) Eastern Ghats & Sri Lanka

(C) Kerala & Sri Lanka (D) Western Ghats & Sri Lanka

14. Name this Hotspot which hosts the two highly threatened species of Caucasian turs or mountain Goats. This Hotspot comprises of deserts, savannas, arid woodlands and forests.

(A) Cerrado (B) Irano-Anatolian

(C) Caucasus (D) Mountains of Central Asia

15. Name this Hotspot whose flora is considered to be drama! c as its 22,500 endemic vascular plant species are more than four ! mes the number found in all the rest of Europe.

(A) Portugal (B) Mediterranean Basin

(C) Mediterranean Sea (D) Morocco

16. This Hotspot called the Mountains of Central Asia comprises of two of Asia's major mountain ranges. The Mountains of Central Asia were known to early Persians as the

(A) "roof of the world." (B) "sky of the world."

(C) "height of the world." (D) "crown of the world."

17.Name this hotspot which is most known for being the home of the giant sequoia, the planet's largest living organism and its taller but less massive rela! ve, the coastal redwood.

(A) California Floris- c Province (B) Madrean Pine –Oak Woodlands

(C) Puerto Rico (D) Texas Floris- c Province

Answers:

1. A	**2.B**	**3.C**	**4.D**	**5.D**	**6.C**	**7.B**
8.A	**9.A**	**10.B**	**11.C**	**12.D**	**13.D**	**14.C**
15.B	**16.A**	**17.A**				

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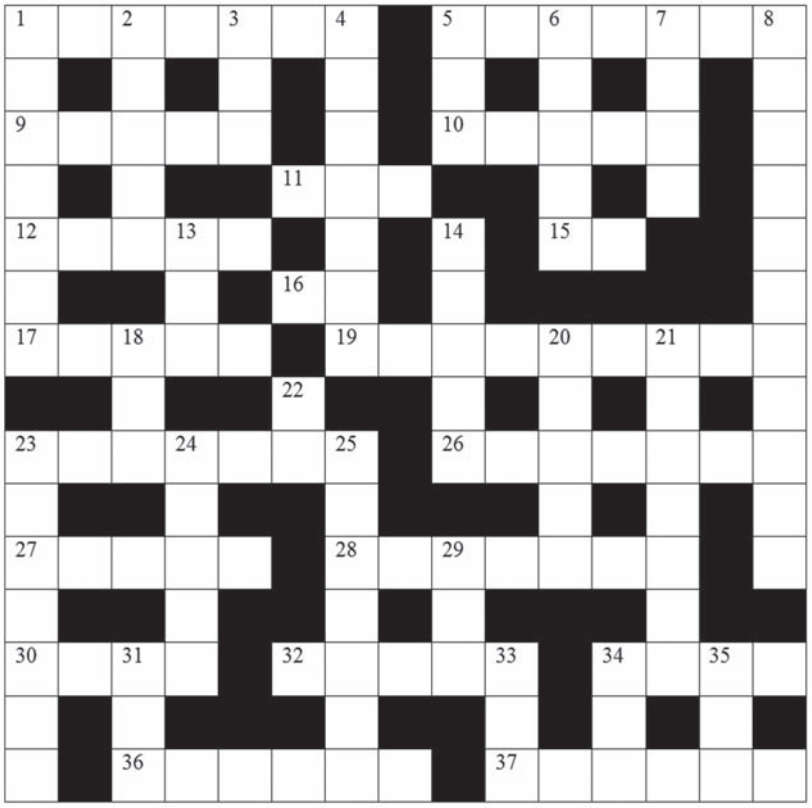
CrossWord



ACROSS

1. The point at which a celestial body in its orbit is closest to earth (7)
5. The flora and fauna of the sea-bottom (7)
9. The "Demon Star", Beta Orionis or _____ is the most familiar of the eclipsing binaries and the first of its type to be known (5)
10. India's first sounding rocket was launched from _____ (5)
11. The _____ of the horizon is the angle which is a function of the altitude of the observer (3)
12. Swiss mathematician of the eighteenth century (5)
15. This element was first discovered in the spectrum of the sun (2)
16. The soft silvery-white element discovered by spectrum analysis (2)
17. Last Greek alphabet (5)
19. The point on the earth's surface directly above the centre of the earthquake (9)
23. A branch of mathematics (7)
26. A moon of Uranus (7)
27. It is the juvenile stage of an insect which differs markedly from the adult (5)
28. An instrument used in Chemistry Lab for measuring fluid (7)
30. The driving mechanism of a boat or ship is situated at the _____ (4)
32. It is the only male resident in a colony of bees (5)
34. A self luminous gaseous celestial body (4)
36. A trigonometric function (6)
37. He propounded the three laws of planetary motion (6)

DOWN

1. A medicine that is given to a patient more for psychological reasons (7)
2. The second brightest star in Orion (5)
3. A jelly-like semi-solid material (3)
4. A conic section (7)
5. Binary digit (3)
6. Polaris is known as the _____ star (5)
7. A type of explosive ammunition used against armoured vehicles also known as High Explosive Plastic (HEP) in US (4)
8. A small fish with spines inhabiting the rivers (11)
13. It records the electrical activity of the brain by means of electrodes and sensors attached to the head (3)
14. A reddish-brown addictive drug which is used as a narcotic (5)
18. A unit of CGS system (3)
20. A white heron of several species (5)
21. The limiting case of a secant when the two points of intersection coincide (7)
23. A flap on an aeroplane wing for balancing (7)
24. Young of eel (5)
25. The pain-relieving drug acetylsalicylic acid (7)
29. A satellite of Uranus (3)
31. A part of the circle or curve (3)
33. The wapiti or _____ is one of the largest land mammals in North America (3)
34. The fluid that circulates in the vascular system of a plant (3)
35. Any member of the Hominoidea superfamily of primates (3)

Contributed by Dr. S.K. Gurtu, 80/158, Mansarovar, Jaipur

Solution
December 2014 Crossword

A	G	A	R	O	S	A	■	S	A	V	A	N	N	A
G	L	O	B	U	L	I	N	M	■	A	■	■	■	P
A	E	I	N	O	S	I	T	O	L	G	■	O	■	H
R	N	■	C	E	R	E	■	G	■	U	■	C	■	O
C	O	B	A	L	T	■	■	■	■	S	■	T	I	T
■	I	I	R	■	■	E	L	V	E	R	■	E	R	I
■	D	L	O	■	■	■	■	■	14	E	N	T	I	C
Z	■	E	T	H	I	D	I	U	M	■	C	■	S	■
Y	D	G	I	Z	Z	A	R	D	■	■	H	S	M	K
M	O	■	D	I	A	P	A	U	S	E	O	Y	I	U
O	D	■	■	■	P	■	■	■	■	M	R	R	C	P
G	O	U	T	■	E	■	■	■	■	E	I	I	E	F
E	■	■	■	■	S	■	■	■	■	U	O	N	L	F
N	Y	C	T	A	L	O	P	I	A	■	N	X	L	E
T	O	C	O	P	H	E	R	O	L	V	I	P	E	R